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SYMPOSIUM ON

The Interrelationship of Oral and Systemic Disease

LESTER W. BURKET, D.D.S., M.D.
CONSULTING EDITOR

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SYMPOSIUM ON THE INTERRELATIONSHIP OF ORAL AND SYSTEMIC DISEASE

Foreword

In the early decades of dental practice, the dentist's scope of interest, activity and responsibility was primarily "tooth-centered." He assumed the responsibility for filling decayed teeth, replacing missing members of the masticatory apparatus and fashioning "plates" for the edentulous patient. The dentist developed a high degree of proficiency in performing these procedures and he became recognized and respected by his medical colleagues and the patients treated as a highly skilled technician. These restorative and prosthetic services were requested and supplied chiefly for esthetic reasons. The American dentist thus achieved world-wide recognition for his technical accomplishments; however, the practice of dentistry was in truth more of an art than a science. The patient was considered more as a walking manikin than as a health problem.

As the decades passed, an increased interest in and emphasis on functional dental services developed. This indicated an awareness on the part of the dentist that in addition to the improved esthetic considerations in his patient, he was also responsible for improved functional relations of the chewing apparatus. While more emphasis was placed on the functional consideration of dental service, this was more of an academic than a clinical development. It became apparent that the science of dentistry was dependent upon a more complete knowledge of the anatomy, physiology and pathology of the structures of the oral cavity. Further refinement of the technical procedures required a better understanding of the biologic sciences and the development of new materials. The interdependency of the biologic sciences and the technical procedures of dental practice became more generally appreciated. Dentistry at this stage, however, was still primarily "tooth and technique centered."

In the early 1920's the focal-infection enthusiasm brought the dentist, the physician and the patient together in an attempt to solve many of the ills which were unresponsive to the treatment currently

employed by the physician. Too frequently, all of the patient's teeth, suspicious or otherwise, were removed. It is now recognized that many teeth were sacrificed needlessly during this period. This intense interest in focal infection brought to the attention of the dental and medical professions and the public the potential importance of oral health to general health and the many interrelationships between oral and systemic disease.

While the focal-infection enthusiasm is now of historical interest, it served a most worthwhile purpose in focusing the physicians', the dentists' and the patients' attention on dentistry as an agency of health. Since this time, the dentists' interest has become increasingly "patient-centered" in contrast to the early "tooth-centered" approach. While the anatomic field of operation of the dentist, the oral cavity, is limited by well defined boundaries as far as other medical specialties are concerned, it has become increasingly appreciated that the procedures performed by the dentist must be considered in terms of the patient as a biologic entity. The oral cavity can thus be considered analogous to other body cavities. This area and its contained structures, along with the rest of the body, has a common source of nutrition. The oral tissues are also governed by the same physiologic principles and physico-chemical laws. Simply stated, the oral cavity cannot be considered apart from the rest of the body, for it is an integral and necessary part of the total patient.

The environmental features of the oral cavity are unique and they present certain peculiarities not found in other body cavities. These environmental and anatomic features assume significant importance in the numerous interrelations between oral and systemic disease. The dental and soft tissues of the oral cavity are in direct communication with the external environment and in indirect communication with the nares and the air and food passageways. The oral tissues are thus subjected to a wide variety of stimuli and foreign agents. The tissues of the oral cavity receive varying traumatic, chemical and thermal stimuli of an intensity unequaled in any other body cavity. These stimuli occur during functional activities such as eating or speaking as well as during common habits such as smoking or consuming alcoholic beverages. The varied microbial population of this area in conjunction with the other stimuli mentioned results in the oral tissues being sensitive indicators of the general health status of the patient. Thus, subtle changes in the color or character of the oral tissues may serve as important diagnostic aids when the clinician is familiar with the appearance of the oral tissues in the healthy state.

As a result of the environmental peculiarities of the oral cavity

mentioned, changes in the tongue, oral mucosa and tooth-supporting tissues frequently manifest the first indication of more remote disease processes within the body. This is especially true with many of the nutritional deficiencies, endocrine disturbances, blood dyscrasias and some of the chronic degenerative diseases. Osler called attention to the oral cavity as a mirror of the general health of the patient. This is indeed true if one will but appreciate the subtle changes in these tissues. Changes in the appearance of the oral tissues may serve an important role in diagnosis even when the oral lesions are not diagnostically specific for a particular disease entity. Changes in the tongue, oral mucosa and tooth-supporting tissues are as significant clinically, and are more readily observed by the clinician, than those occurring in the eye grounds.

As dentistry has become "patient-centered" rather than "tooth-centered" in terms of diagnosis and treatment, it has justified its position as a member of the health professions. In present-day practice of this health profession, the intelligent and understanding performance of the restorative or prosthetic phases of dental service requires a thorough knowledge of the anatomic structures and the physiologic principles of the parts involved by the disease process to attain the highest achievable level of health service.

The general recognition and the understanding of the interrelationship of oral and systemic disease by the dentist represent a comparatively recent development in the dental profession. This phase of practice, which is concerned primarily with the non-biomechanical phases of dental practice, is commonly referred to as oral medicine. Oral medicine can thus be considered as a bridge between the biomechanical phases of dental diagnosis and treatment and clinical medicine. As all dental and medical care becomes primarily "patient-centered," oral medicine will assume increasing importance. While it is not possible to give a more concise definition of this field, it bears the same general relation to dental practice as internal medicine does to medical practice.

The interrelationships between oral and systemic disease are many and significant, as the different articles in this volume will indicate. They should be recognized and understood by both the dentist and the physician. In fact, the general practitioner of medicine might profit as much as the dentist from a careful review of this volume of the Clinics. It is indeed surprising that medical education fails to consider this important region of the body in respect to its significant usefulness in the diagnosis of systemic disease. As the many interrelationships of oral and systemic disease become better understood and

appreciated, the cooperative efforts of the physician and dentist will be employed on a wider basis. This will make for a higher level of health service for the patient. It is hoped that both the dentist and the physician will become familiar with the phases of oral medicine presented in this issue of the Clinics so that their patients might receive a more comprehensive health service.

As the science of dentistry has developed in recent decades, the dental profession has become more generally appreciated by the public as one of the major health services. The dentist, and perhaps the physician, are still too often concerned primarily with the disease itself and its treatment, rather than the patient as a biologic unit experiencing some organic or functional disturbance. Treatment should be planned and directed for the individual patient rather than for a particular disease.

The knowledge of the lesions of the oral mucosa, tongue, teeth and their supporting tissues associated with general disease states has increased markedly. The dentist can no longer limit his interest in the patient to the oral cavity if a true health service is to be furnished. The dentist can no longer fulfill his responsibility to the patient by diagnosing and treating only lesions of local origin. The scope of health services of dentistry and the responsibility of the practicing dentist have become broadened accordingly, and today the dentist is considered by education and by experience as the physician as well as the surgeon of the oral cavity. Disease processes appearing in the mouth therefore must always be considered in relation to the general health of the patient, or to medication which the patient may be receiving from the physician.

The dentist must first determine whether the oral lesions are of local etiology and hence primarily of local significance. Even when local etiologic agents are considered to predominate, the dentist must consider whether there are any systemic contraindications to the proposed plan of treatment. This will require an evaluation of the general health status of the patient and an understanding of many of the diseases treated by the general practitioner of medicine. Consultation with the patient's physician and cooperative treatment are becoming a more routine procedure resulting in a high level of comprehensive health service.

The dentist has other responsibilities which necessitate a general evaluation of the patient prior to instituting treatment for oral lesions. With the more widespread use of powerful and hence potentially dangerous drugs for many chronic diseases, it is particularly important that the dentist be aware of any and all medications the patient may

be receiving from his physician. The dentist must also have an adequate knowledege of the pharmacology of the newer drugs and be familiar with the dental implications of these therapeutic agents that are being prescribed extensively by the physician. At times, their use will necessitate considerable revision of the customary dental treatment planning, and in some instances dental surgical procedures on the soft tissues will even be contraindicated. For example, patients receiving anticoagulants or the corticosteroids will require special consideration if deep gingival curettage or extractions are indicated for local disease processes. Unfortunately, the physician does not routinely inform the patient of the need for acquainting the dentist of the nature of the medication being prescribed. The attention of the reader is called to this important phase of oral medicine, which is discussed elsewhere in this issue.

The dentist has an equal if not a greater responsibility in the recognition of the possible systemic etiology of an oral lesion for which the patient consults him. This phase of oral medicine will receive attention in all articles in this issue. These oral lesions may appear on the gingiva, the tongue, the lips or the oral mucosa long before the generalized manifestations of the disease have developed to a degree which will cause the patient to consult the physician. At times the roentgenograms of the teeth and jaws, made periodically by the dentist, may furnish the first clue to a systemic process before the typical symptoms appear in other body areas. These case-finding potentialities and opportunities of the dentist should be employed on a wider and more general scale in the field of preventive medicine, for a better health service for the physician's and dentist's common patient.

The recognition by the dentist of the systemic basis for an oral lesion has a dual significance. Treatment on a local symptomatic basis would be unsatisfactory, or at best, only a transitory favorable response would be obtained which would be frustrating to the dentist and discouraging to the patient. More important, attempts to treat the oral lesion as a local process will delay specific treatment for the underlying systemic condition. This delay of rational or specific therapy minimizes the patient's chances for a prompt and effective response to therapy. In some instances the early recognition of the systemic basis for the oral lesions by the dentist may even be lifesaving for the patient. The dentist, therefore, should always remember that first he is treating people, and secondly oral mucosal, gingival or dental diseases. His interest should be "patient-centered" rather than "tooth-centered." He should treat a patient with a disease, and not the disease. This

broader concept of the scope of dentistry, coupled with the dentist's and the physician's increased awareness of the field of oral medicine, will result in a higher level of health service to the patient. This type of health service will stress prevention and emphasize the feeling and appearance of well-being rather than the absence of disease. Dentistry, when practiced with this philosophy, can truly qualify as an agency of health.

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Preventive Medical Case-finding Opportunities and Responsibilities of the Dentist

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It is the purpose of this article to consider how the dentist can best serve as a member of the health team. More specifically, it is our cardinal concern to analyze the role of the dental practitioner in the detection of systemic disease. The idea that the stomatologist can and should play an integral role in this program is not new. This thought has occurred to many members of both the medical and dental professions. This concept has been tossed about in both the professional and lay literature. However, despite the talk and the writings, little actually has been accomplished to show beyond any question that the dentist is playing his part in the over-all health program.

In order to clarify the role that the dentist should and can take in the health program, this paper will be divided into three parts: (1) a rather basic consideration of the nature of disease in general, (2) the place of the oral cavity in the over-all picture of disease states, and finally, (3) the role of the dentist in the detection of systemic pathoses.

THE NATURE OF DISEASE

There are two inescapable features about disease processes which are peculiarly pertinent to this discussion. They are (1) that a pathologic process is the result of *more than one* operating factor, and (2) that health and disease seldom become clinically apparent in pure blacks and whites—in other words, that sickness and health are *relative* states which are usually demonstrable in a series of shades of gray. Because of the importance of these two aspects of disease, they will now be considered in some detail.

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Disease a Product of Multiple Factors

The Layman's Observations. The point that more than one factor is required to cause disease is abundantly evident to the man on the street. It is a common experience for two persons, simultaneously drenched in a rainstorm, to fare very differently. Mr. A. contracts a severe upper respiratory infection or even pneumonia and may possibly die. Mr. B. remains unscathed. This type of crude observation suggests that the very same insult, in this instance chilling, yields different results because of differences in people. The layman calls this *difference* by many names—most often *resistance*. And so it is that we hear in common parlance that "he caught a cold because his resistance was low."

The Experience in Medical Practice. The point that more than one factor operates in the causation of disease is also plentifully evident in everyday medical practice. For example, a seemingly healthy person (at least free of any symptoms and signs) steps out into the bright sun. Shortly thereafter he notes a dermatitis. The examining physician, with almost cursory inspection, recognizes that the character and distribution of the lesions can only mean one thing—pellagra. No one will argue that Mr. X was just as pellagrous the day before the actinic exposure. This illustration emphasizes that a suitable systemic substrate, in this instance a niacin deficiency, can exist unnoticed until some local insult, in this case the sun rays, does something to bring about a net result which is clinically recognized as proof of sickness.

The Experience in Dental Practice. Examples of the interplay of local trauma and an appropriate systemic substrate are not confined to observations by the layman, nor are they restricted to the sphere of medicine. In fact, there is every reason to believe that these same interrelationships are as important, if not more so, in the oral cavity. For example, it is common knowledge that two patients may present themselves in the dental office with abundant and, within limits, equal, amounts of calculus. Yet, in one individual there is no alveolar bone loss whereas in the other there is extensive bone destruction. Obviously, the calculus *alone* cannot be considered to be the *cause* of the bone picture. Illustrations of this same type are plentiful in dental practice.

It would appear from these few, simple examples that the *observable* pattern of disease fits into a formula which may be expressed as follows:

Systemic substrate $\times$ Exciting factor $=$ Observable evidence of disease

The clinical cases cited and the formula shown above represent attempts to underscore the point that a pathologic process is the result

of more than one causative factor. The question which now arises is why clinical (observable) proof of disease should equal the *product* rather than the *sum* of a suitable systemic substrate and an appropriate exciting factor as shown on the left side of the above equation. The answer to this question may be found by analyzing the examples already presented.

It should be recalled that the pellagrin was asymptomatic and free of signs of disease until he stepped out into the sun. In other words, as long as there was no exciting factor of critical threshold, in this instance no cutaneous trauma, this variable in the equation was zero. The arithmetic of this example is shown in the following equation:

$$\begin{array}{ccccc} \text{Systemic substrate} & \times & \text{Exciting factor} & = & \text{Observable evidence of disease} \\ \text{Niacin deficiency} & \times & 0 & = & 0 \end{array}$$

Thus, regardless of the systemic imbalance, the niacin deficiency alone does not produce clinical proof of disease. The right hand side of the equation is zero.

It would appear logical, then, that the converse might also be true. In other words, had the patient not had aniacinosis, if this factor were now zero, then regardless of the actinic exposure, the product would once again be zero. There would not be the typical pellagrous dermatosis, as shown in the following equation:

$$\begin{array}{ccccc} \text{Systemic substrate} & \times & \text{Exciting factor} & = & \text{Observable evidence of disease} \\ 0 & \times & \text{Actinic exposure} & = & 0 \end{array}$$

In the final analysis, it is rare, if not impossible, to eliminate (reduce to zero) either of the variables on the left side of the formula. This is so because disease states are not clinically observable in simple blacks and whites but rather in an infinite number of shades of gray—in other words, in *degrees*.

Degrees of Disease

There is no argument that a person can be seemingly very healthy or undeniably sick. These are the blacks and whites of disease. However, too little attention is directed to the fact that there are *degrees* of sickness and well-being. In all probability, white (perfect health) is never attainable. Black, at the other pole, represents disease in its

classic form. Between these two limits are an infinite number of shades of gray—a limitless gradation of health to sickness.

This concept of degrees is not without clinical support. The clinician is constantly confronted by the patient who is clinically well today and clinically ill ten years hence. Surely, the patient with diabetes mellitus, rheumatoid arthritis, ascorbic acid deficiency, to pick but a few examples, does not develop his illness overnight. But more relevant to this discussion is the person who at age twenty has no alveolar bone loss, who continues to be well but yet at age fifty shows severe alveolar bone loss. Obviously, this picture did not develop in a week, a month, or a year. During the thirty year interval between white (age twenty) and black (age fifty), the patient cannot have been in perfect health. The question now is, "How does this new information fit into the formula?"

For illustrative purposes only, let us assign numbers to the two variables on the left side of the formula. Let us say that there are gradations from zero to ten. Zero for the first variable in this scheme indicates a perfectly healthy systemic substrate. Zero for the second variable signifies the complete absence of any exciting factors. Translated into a practical situation, we are confronted with a subject who has absolutely no systemic disorder. Also, in this hypothetical situation, the patient is free of calculus, there are no overhanging restorations, the occlusion is perfect.

Systemic substrate	×	Exciting factor	=	Observable evidence of disease
0	×	0	=	0

On the other hand, we shall assign the value ten to each of the two factors on the left side of the equation. For example, a factor of ten means that the patient is suffering with diabetes mellitus in its classic form with polyuria, polyphagia, polydipsia, weight loss. A value of ten for the second variable signifies abundant calculus, a host of ill-fitting restorations, marked occlusal imbalance, etc.

Systemic substrate	×	Exciting factor	=	Observable evidence of disease
10	×	10	=	100

The value on the right of the equation is high, representing the presence of many and marked symptoms and signs of disease. Thus, in the diabetic patient who meets these specifications, there are polyphagia, polyuria, polydipsia, weight loss. In addition, there are marked gingivitis, extensive alveolar bone loss, possibly a history of slow postextraction healing, perhaps gingival bleeding, etc. The clinical evidence is clear—the patient is indeed systemically ill and there are plenty of oral symptoms and signs to prove it.

The two extremes, the $0 \times 0 = 0$ and the $10 \times 10 = 100$—the whites and the blacks—are simple to comprehend. But there are many other possible combinations:

Systemic substrate	×	Exciting factor	=	Observable evidence of disease

Equation A

Severe diabetes mellitus		Minor local trauma		
10	×	1	=	10

Equation B

Mild diabetes mellitus		Marked local trauma		
1	×	10	=	10

Equation A represents a severe diabetic patient with only minor local (oral) irritating problems. We note on the right side of the equation the value ten. This means that there are some observable symptoms and/or signs of disease. Translated into clinical terms, the ten on the right side of Equation A may represent minimal alveolar bone loss in a *severe* diabetic patient with *minimal* oral trauma. Equation B shows the same end result, a value of ten. In this case, we are faced with a *mild* diabetic subject with *marked* local irritation.

All of the combinations thus far analyzed are clinically demonstrable. However, even more often the clinician is faced with a *mild to moderate* diabetic patient with *mild to moderate* local oral trauma. In clinical parlance, the examiner is confronted with a patient with minimal alveolar bone loss who appears, for all practical purposes, to be perfectly well.

Systemic substrate		Exciting factor	=	Observable evidence of disease
(Mild diabetes mellitus)		(Minor trauma)		
3	×	3	=	9

We have now established a formula for health and disease. The question which now arises is, "How does the oral cavity fit into this equation?" In order to answer this very important question, one must analyze the structure and function of the mouth.

THE ORAL CAVITY

The mouth is a most unusual area of the body. This is so because (1) it is, in many respects, exactly *like* other regions, and at the same time, (2) it is *unlike* any other part of the body. This is true from both a *structural* and a *functional* standpoint.

The Structure of the Oral Cavity

Generally speaking, the mouth is very much like other mucosa-bounded cavities. It is lined by an epithelium much like that of the vagina, the anus, and the nose. Beneath the mucosa are various types of connective tissue histologically similar to their homologues in other parts of the body. Thus, with such structural similarities, it is understandable why changes in the oral tissues parallel alterations in like tissues elsewhere in both health and disease. Herein lies the explanation for the simultaneous cyclic epithelial changes in the oral and vaginal mucosae during physiologic menstruation and the climacteric. This is the basis for the similarity of cutaneous and mucosal lesions (e.g., intestinal polyposis and angioneurotic edema).

At the same time, there are cells and tissues in the mouth which are truly unique in that they are not found elsewhere. The teeth and the associated periodontal structures are the most striking examples. The presence of the odontogenic apparatus makes the oral cavity special in two different ways: (1) problems arise in the mouth, notably dental caries and periodontal disease, not encountered anywhere else in the human body, and (2) the oral symptoms and signs of systemic disease states are modified by the presence of the special cytoarchitecture of the teeth and the periodontium. Thus, simply by way of example, the oral findings of plumbism and pityriasis are far different from the evidence of these same diseases in the leg, or abdomen, or chest.

The discussion of the anatomy of the mouth can be simply summarized. First, the oral tissues are like their counterparts elsewhere. In other words, epithelium is still epithelium and fibrous tissue basically remains fibrous tissue. Consequently, a so-called collagen or bone disease implicates the collagenous or osseous elements wherever they may be. And so, understandably, systemic diseases do have their oral reflections. But secondly, the oral tissues are in some anatomic respects quite unique. Hence, problems arise in the mouth which are not encountered elsewhere. Thus it is that the filiform papillae of the tongue atrophy in various nutritional disorders. So it is that the teeth become subclinically more mobile during the pregnancy state.

The Function of the Oral Cavity

Not only is the mouth *structurally* like and unlike similar cavities, but it is also *functionally* like and unlike other mucosal orifices. The similarities require little elaboration. What are more important are the differences—the unusual functional demands placed upon the oral tissues.

The mouth, it should be recalled, is expected to participate in a host of vital functions, notably speech and mastication. Within the very same breath, the oral mucosa is expected to tolerate high temperatures (boiling coffee) and low temperatures (freezing ice cream). No other tissue of the body is asked to withstand such insult. It is of parenthetic interest that when one conducts a similar experiment on the supposedly tougher skin, an erythema results. Yet the mouth is expected to, and does, handle such constant microtraumata. *The oral tissues, it must be emphasized, can only weather such persistent local irritation as long as the systemic substrate is in good health.*

This last point bears directly on the present discussion of a formula for disease. This, as we shall learn, is directly pertinent to the analysis of the dentist's role in the detection of systemic disease.

We have already observed that the *product* of a systemic substrate and an exciting factor yields observable evidence of disease. Now we add that, under so-called physiologic conditions, oral irritation is high. Thus, in our formula, we might say that local trauma is to be assigned a value of 3, or 4, or 5 or more. It then becomes clear that the higher the value on the left side of the equation, the greater will be the product of the two variables on that side. Or, to put it another way, *observable evidence of a systemic disease in the oral cavity is very apt to be present even when the systemic substrate is minimally pathologic.*

The Mouth as a Barometer of Systemic Disease

And so it is that systemic disease often makes its clinical debut by way of oral symptoms and/or signs. This is so because, though both the systemic disease and the local irritation are often of a relatively low magnitude, their product is great enough to produce complaints or visible findings in the oral tissues.

THE FORMULA OF DISEASE

The equation which has just been developed suffers from one great fault—its simplification. It implies that there are but two variables, systemic substrate and exciting factor. It suggests or implies, to pursue our example, that a patient must be diabetic and must, in addition, have calculus. Actually, each of these factors in the equation may indeed be a host of variables. Is it not conceivable that a patient may be a very mild diabetic, suffering with early rheumatoid arthritis, complicated by a marginal ascorbic acid deficiency? Is it not further possible that there may be a slight collection of calculus, imperceptible overhanging restoration(s), minimal occlusal imbalance, in a person

who smokes just a little too much, who grinds his teeth while asleep, and who brushes his teeth a bit too enthusiastically? Thus, in the formula below, *a* might represent mild diabetes mellitus, *b* early rheumatoid arthritis, and *c* marginal ascorbic acid deficiency, with possibly other pathologic problems up to *n*. At the same time, *p* signifies calculus deposition, *q* overhanging filling materials, *r* occlusal imbalance, *s* tobacco irritation, *t* vigorous toothbrushing, and other local irritants up to *x*.

Systemic substrate	×	Exciting factor	=	Observable evidence of disease
$(a+b+c\ldots.n)$		$(p+q+r+s+t\ldots x)$		

THE ROLE OF THE DENTIST IN THE DETECTION OF SYSTEMIC DISEASE

We now see that the dentist is in an admirable position to detect *early* systemic disease. As a matter of fact, the dental practitioner has, in some respects, the advantage over his medical confrere for two reasons. In the first place, oral trauma is high. Therefore, systemic disease will often show up in the mouth before it can be recognized elsewhere. Secondly, it is of some interest that approximately only one-twentieth (5 per cent) of the physician's time is spent in the routine examination of so-called healthy folks. In other words, more often than not, people visit the physician only when they are ill. In contrast, more and more apparently well persons are visiting the dentist regularly for periodic examinations. *This is the time, the optimal time, to detect early systemic disease.*

Systemic Diseases with Oral Manifestations

Actually, there are over 200 systemic diseases which, at some point in their clinical course, show oral symptoms and/or signs. In some cases, the oral findings *precede* the clues elsewhere. This is classically illustrated by the Koplik's spots which precede, by 24 or more hours, the cutaneous eruption of measles. In other disorders, the oral findings *parallel* those in other areas. The enanthem of chickenpox falls into this category. Finally, there are situations where the oral changes *follow* the symptoms and signs in other parts. This sequence may occur, for example, in lupus erythematosus.

Needless to say, it is impossible in these few pages to list, let alone discuss, all of the oral manifestations of all of the systemic diseases. Nor is this necessary since such accounts are readily available in the literature. Rather, an attempt will be made to show, *by example*, how

the oral cavity fits into the general picture of systemic disease and how the dental practitioner can serve in the detection of such disorders.

Case Report No. 1. Among the varied causes for systemic diseases, some are due to chemical agents. Sometimes, the cause for the chemical intoxication is occupational—the agent is ingested, inhaled, or is absorbed from the body surface. Occasionally, the drug is taken for suicidal purposes. Finally, chemical intoxication may be a sequela following the ingestion of an agent for medicinal purposes. The case to be described falls into the latter category.

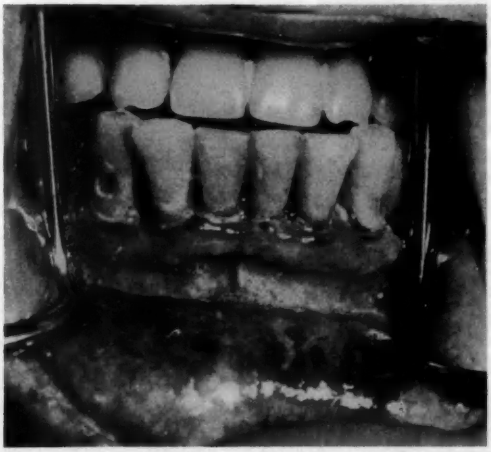

Fig. 1. A middle-aged white woman with a chief complaint of excessive salivation and sore mouth. Examination reveals full upper dentures, only natural teeth are lower anterior ones, end-to-end bite, gingival recession and blue-black subepidermal pigmentation in the marginal gingiva.

Findings. This middle-aged white woman was admitted to the hospital with a chief complaint of excessive salivation and sore mouth. Examination of the oral cavity revealed full upper dentures and only the lower anterior teeth remaining (Fig. 1). There was an end-to-end bite with obvious traumatic occlusion. There was also considerable gingival recession and blue-black subepidermal pigmentation in the marginal gingiva.

The patient reported that she had no oral complaints until four months previously. Interestingly enough, it was at that time that she was first given mercurial diuretics because of refractory cardiac decompensation. Shortly thereafter her cardiac status improved and the diuretics were discontinued. She reported that her oral complaints improved. However, because the cardiac failure could not be satisfacto-

rily controlled with digitalization, the mercurial diuretic was resumed. Once again her mouth became sore and salivation increased to the point that her hospitalization become necessary, not because of her cardiac status but because of the oral picture.

Comments. Here is a patient who is subjected suddenly to relatively small amounts of mercury. This is a common practice, since mercury paralyzes the renal tubules and so decreases tubular reabsorption of water. Thus, there is greater fluid loss and a reduction in cardiac edema. The important point to emphasize is that this patient developed a mild case of mercurialism.

In our formula, then, we now have a systemic substrate of some magnitude. Let us assign the value of 5:

Systemic substrate (Mild mercurialism)	×	Exciting factor	=	Observable evidence of disease
5	×	0	=	0

If the oral cavity were in perfect health, then the other variable would be zero and the product (no observable evidence of disease) would be zero. However, this patient, with full upper dentures, only a few lower teeth and an end-to-end bite, was obviously suffering with occlusal stress. Parenthetically, the point should be made that diseased tissue liberates hydrogen sulfide. Also, the evidence is clear that circulating heavy metals unite in diseased tissue with hydrogen sulfide and become deposited as, in this case, mercuric sulfide. Finally, the few remaining teeth were expected to carry the impossible load for all of the lower teeth. Thus, the other variable in the equation (local trauma) is certainly not zero. Let us, arbitrarily, assign to it a value of 5 as shown in the following equation:

Systemic substrate (Mild mercurialism)	×	Exciting factor (Traumatic occlusion)	=	Observable evidence of disease
5	×	5	=	25

The evidence in this case suggests that, had there been no oral irritation, there would have been no oral complaints. The evidence also suggests that, had there been no mercurialism, there would not have been oral findings.

Case Report No. 2. Frequent reference has been made in this paper to diabetes mellitus. It might, therefore, be well to analyze one such case as it presented itself in the dental office.

Findings. This 31 year old woman was referred to the dental clinic for full mouth extraction because of extensive, generalized alveolar bone loss and considerable tooth mobility, most obvious in the lower

Fig. 2. A 31 year old woman with a chief complaint of moderate mobility of all of teeth and especially the lower central incisor. The gingivae appear normal in color, position, shape, contour and consistency.

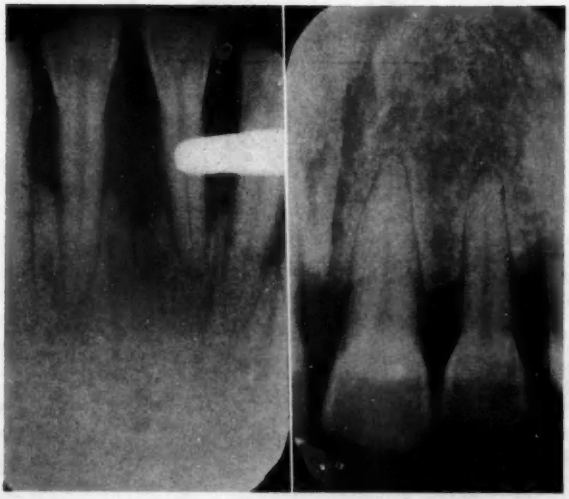

Fig. 3. Representative periapical roentgenograms showing the generalized alveolar bone loss.

central incisor. There was occasional gingival bleeding. Oral examination revealed reasonably normal gingiva but moderate tooth mobility (Figs. 2 and 3). As part of the routine diagnostic workup on all patients with tooth mobility, a glucose tolerance is done. The patient's glucose tolerance curve is shown in Figure 4. It is clear that the patient is suffering with diabetes mellitus despite the absence of the

classic symptoms and signs of this disease. She was referred to the diabetic clinic where the diagnosis was confirmed and an appropriate diet prescribed. When next observed three months later, the patient stated that she had been resting better, did not fatigue as easily, and that her teeth, and particularly the lower central incisor, were not as loose.

Comments. Here is a young lady who presents herself in the dental clinic with complaints almost exclusively confined to the oral cavity.

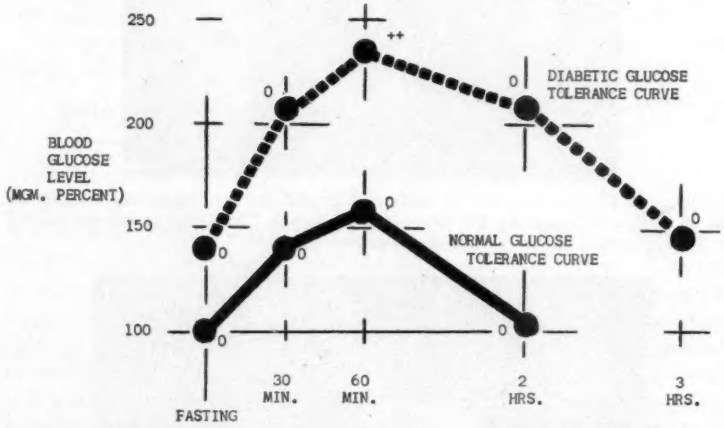

Fig. 4. The glucose tolerance curve of the patient compared to that of a non-diabetic patient. The small zeros and the ++ indicate the absence and presence of sugar in the urine. It is of interest that the fasting urine was sugar free and the fasting glucose level was within normal limits.

It should be emphasized that the patient did not show any of the *classic* evidence of diabetes mellitus. Hence, in our equation, we shall assign some intermediate value to the systemic substrate. As we have seen, local trauma was minimal (possibly of a magnitude of 2 or 3). And so, the formula now is:

Systemic substrate	×	Exciting factor	=	Observable evidence of disease
(Mild diabetes mellitus)		(Minimal occlusal trauma)		(Insidious bone loss)
5	×	2	=	10

Case Report No. 3. This last case is included because it provides the rare opportunity to observe the interplay of local and systemic factors and also allows the chance to show the effects of modifying these two variables independently.

Findings. This 15 year old girl was first observed in the dental clinic because of a history of bleeding with toothbrushing from the embrasure between the left maxillary second premolar and first molar. Oral examination proved negative except for an ill-fitting MOD amalgam restoration in the first molar with an overhang into the embrasure. The only other findings of importance were seemingly spontaneous ecchymoses in the skin and a very poor history of citrus intake. Her

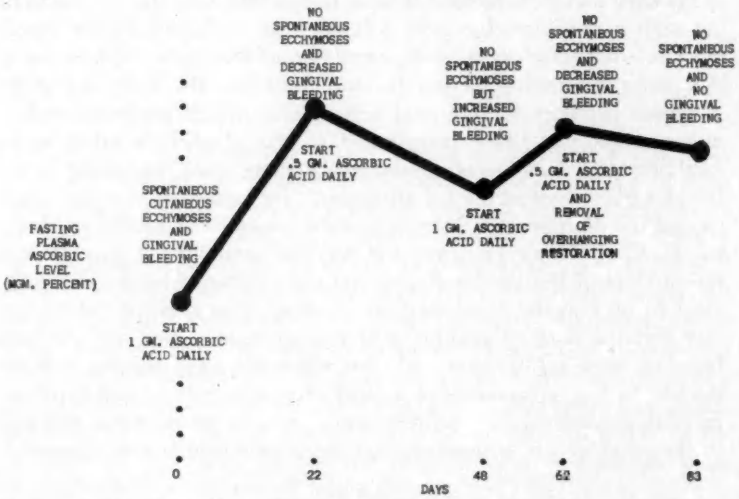
FASTING PLASMA ASCORBIC LEVEL (MGM. PERCENT)
SPONTANEOUS CUTANEOUS ECCHYMOSES AND GINGIVAL BLEEDING
START 1 GM. ASCORBIC ACID DAILY
NO SPONTANEOUS ECCHYMOSES AND DECREASED GINGIVAL BLEEDING
START .5 GM. ASCORBIC ACID DAILY
NO SPONTANEOUS ECCHYMOSES BUT INCREASED GINGIVAL BLEEDING
START 1 GM. ASCORBIC ACID DAILY
NO SPONTANEOUS ECCHYMOSES AND DECREASED GINGIVAL BLEEDING
START .5 GM. ASCORBIC ACID DAILY AND REMOVAL OF OVERHANGING RESTORATION
NO SPONTANEOUS ECCHYMOSES AND NO GINGIVAL BLEEDING
0
22
48
62
83
DAYS

Fig. 5. A pictorial representation of the fasting plasma ascorbic acid level of a 15 year old girl. The patient had a marginal ascorbic acid deficiency and local irritation due to an ill-fitting restoration, with resultant gingival bleeding associated only with toothbrushing.

fasting plasma ascorbic acid level proved to be marginal (0.62 mg. per cent).

She was started on a regime of 1 gm. of ascorbic acid by mouth daily in divided doses (250 mg. four times a day), as shown in Figure 5. When seen four days later, *the patient reported that both the ecchymoses and the toothbrush bleeding had subsided.* However, the ascorbic acid regime was continued. On the twenty-second day (Fig. 5), because of no ecchymoses and decreased gingival bleeding, the ascorbic acid dosage was halved. The plasma ascorbic acid level was then 1.4 mg. per cent (roughly more than twice that on admission). When observed about three weeks later, on the forty-eighth day, *the gingival bleeding had reappeared* while the plasma level was 1.07 mg. per cent. The 1 gm. per day ascorbic acid regime was re-instituted. Two weeks later, on the sixty-second day, the plasma level was 1.33

mg. per cent. Most interestingly, the *gingival bleeding had again subsided.* This time, the dosage was again halved and the ill-fitting restoration replaced with a more acceptable filling. The fasting plasma ascorbic acid level at the next visit, three weeks later on the eighty-third day, was 1.16 mg. per cent. *The patient reported that the gingival bleeding had vanished completely.*

Comments. This case emphasizes very well the delicate interplay of systemic and local factors. Here is a child who was obviously suffering with a mild ascorbic acid deficiency, as evidenced by the spontaneous cutaneous ecchymoses, even if one wishes to explain away the gingival bleeding on purely local irritation. However, the same increased capillary fragility and permeability which produced ecchymoses might well have contributed to the gingival bleeding with toothbrushing. This seems a likely explanation, since decreasing capillary fragility (without local treatment) by means of ascorbic acid caused the disappearance of the ecchymoses and a reduction in gingival bleeding. However, when the ascorbic acid dosage was halved, the product of the local irritation and the capillary fragility was sufficient to once again cause gingival bleeding. This is borne out by the fact that the dose of ascorbic acid was again increased and gingival bleeding once again decreased. But when the local trauma was reduced (by the replacement of a satisfactory restoration) and capillary fragility diminished (by ascorbic acid), then the product was reduced to the point at which there was no observable evidence of disease.

SUMMARY

An attempt has been made to show that observable evidence of disease, in general, is the product of more than one operating factor. Since oral trauma, even under physiologic conditions, is quite high, the product of it and even a marginal systemic imbalance may be great enough to produce oral symptoms and/or signs. This concept has been underscored by three examples: (1) a disorder due to a chemical agent, mercurialism; (2) a hormonal imbalance, diabetes mellitus; and (3) a nutritional problem, ascorbic acid deficiency.

The analysis of disease in general and the oral cavity in particular described in these pages underscores the fact that the dentist is in an excellent position to detect early systemic disease.

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The Dental Significance of Medication for Systemic Disease

F. Darl Ostrander, D.D.S., M.S.*

With the vast increase in recent decades in the number and types of drugs used in the treatment of systemic disease, it has become increasingly important for the dentist to be familiar with the patient's physical condition and his past medical history. Many of the drugs now in general use in medicine may cause body changes which will necessitate modification of dental procedures or, in some instances, may temporarily contraindicate any form of dental treatment. Other drugs may produce oral manifestations which might be erroneously diagnosed by the dentist if he were not aware of the patient's being under medication with the agent concerned. For these and other pertinent reasons, it is increasingly important that a medical history be taken of the dental patient and that one area of questioning be concerned with current or past drug therapy.

In this brief article it will not be possible to present a complete or detailed description of all possible dental complications from systemic medication, but the most commonly used systemic drugs which produce reactions of dental significance will be discussed along with a brief description of the dental problems they may incite.

ADRENOCORTICAL STEROIDS

A growing number of patients are under treatment with the adrenocortical steroids, cortisone or hydrocortisone, or with corticotropin (ACTH), which stimulates additional secretion of the adrenocortical steroids. Such varied disease states as rheumatoid arthritis and gouty arthritis, allergic states, inflammatory diseases of the eye, pemphigus, ulcerative colitis, pulmonary fibrosis, sarcoidosis, renal disease, blood disorders and hepatic disease are at times treated with this group of

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drugs. Thus it becomes evident that a significant portion of the population is from time to time under treatment with corticotropins or corticosteroids.

Among the side effects which these agents produce is a depression of the natural defensive mechanism of the body, including inflammation. As a result, a patient being treated with this group of drugs is more prone to postoperative infections than normally and when any form of oral surgical procedure is to be undertaken, prophylactic administration of the antibiotics is usually indicated. Since these drugs also suppress the usual early signs and symptoms of disease, they may complicate diagnosis. For example, an acute alveolar abscess might develop almost unnoticed and reach a serious stage before the patient became aware of its presence. Topical application of the corticosteroids may reduce localized inflammatory reactions such as the sore spots under dentures. However, it should be emphasized that such treatment is symptomatic only and in no way eliminates the cause of the condition.

Generally speaking, it is wise to discuss any proposed dental surgery with the patient's physician if a history of current systemic therapy with corticotropin or corticosteroids is elicited.

ANTICOAGULANTS

In the past decade anticoagulant drugs have come into widespread use in medicine and many ambulatory patients are now under such treatment. The most commonly used drugs are bishydroxycoumarin (Dicumarol) and heparin. Since heparin must be given by injection it is most frequently used in the hospitalized patient when a rapid and very active anticoagulant effect is desired. Bishydroxycoumarin can be given by mouth, and many patients who appear to be in good health on casual examination are taking this drug. These drugs are used during and following such conditions as pulmonary embolism, thrombophlebitis, arterial occlusion, venous thrombosis, and coronary occlusion. A great many people take bishydroxycoumarin for extended periods after suffering a coronary occlusion.

Anticoagulant therapy is significant to the dentist in that coagulation time is prolonged and therefore postoperative hemorrhage may follow even simple and uncomplicated surgical procedures. If possible, any oral surgery should be delayed until after the course of anticoagulant therapy is completed. If this is not possible, the patient's physician may be consulted as to the advisability of a temporary interruption of the anticoagulant therapy. If the physician feels that interruption of the use of anticoagulants would be dangerous and the oral surgery

cannot be delayed, then the dentist must anticipate possible hemorrhage and be prepared to take local measures for its control. Topical use of thrombin (with or without a gelatin sponge), oxidized cellulose sponges or other hemostatic agents along with pressure may be considered. The patient should be closely observed until the danger of postoperative hemorrhage appears to be past.

ANTIBIOTICS

An increasing portion of the population has been or is being treated with antibiotics. This may be of considerable significance in planning the therapeutic measures to be taken when severe intraoral infections are encountered.

Penicillin

Of particular significance is the fact that an increasing segment of the population has become sensitive to penicillin. The exact proportion of the population which will react unfavorably to penicillin is difficult to determine. The estimates have run as low as 1 per cent and as high as 8 per cent. The actual figure probably falls somewhere between these extremes. However, the number of sensitized persons is great enough to make it essential to determine whether there is a past history of penicillin reactions before using penicillin either systemically or topically. If there is a history of past penicillin reactions the drug should be avoided because penicillin reactions can be both unpleasant and serious and, rarely, fatal. Most fatalities reported from penicillin therapy have come as a result of anaphylactic reactions; a few fatal cases of exfoliative dermatitis are also to be found in the literature.

There has been an unfortunate concept that topical application of penicillin is less liable to produce sensitization in patients and reactions in the sensitized patient than is systemic administration of this agent. At least so far as original sensitization of the patient is concerned, quite the reverse is true; topical application is more prone to sensitize than either the parenteral or the oral route of systemic medication. Moreover, sensitization reactions can be induced by topical application and there is the possibility of producing resistant strains of organisms. For these and other reasons the Council on Dental Therapeutics of the American Dental Association has deleted all forms of penicillin intended for topical application from *Accepted Dental Remedies*. In the opinion of this writer the hazards of topical application of penicillin usually outweigh the potential benefits and

therefore topical application to the oral mucosa is rarely indicated. When topical application seems necessary, other antibiotics such as bacitracin, neomycin, polymyxin or combinations of them that are commercially available might well be considered as a substitute for penicillin.

Other Antibiotics; Tetracyclines

It should be emphasized that a history of past therapy with other members of the antibiotic group besides penicillin is of significance in dentistry. Some patients show very severe gastrointestinal reactions to the tetracycline group of antibiotics (Aureomycin, Terramycin, Achromycin, Tetracyn). Obviously, if such a history is obtained, the use of this group should be avoided.

Rarely, patients may be sensitive to a wide range of antibiotics and it may be necessary to substitute other anti-infective drugs such as sulfonamides.

CENTRAL NERVOUS SYSTEM DEPRESSANTS

Many people at the present time are under treatment for varying degrees of ordinary nervousness, neurosis or mild psychosis, and usually some form of central nervous system depressant is used for this purpose. In addition, many other conditions, including epilepsy, Parkinson's disease, gastric or duodenal ulcer, menopausal tensions, and insomnia, are treated with the several groups of central depressants.

Barbiturates

Perhaps the most widely used group of central depressants is the barbiturates. Since barbiturates are frequently used in preoperative sedation in dentistry, it should be remembered that a patient who takes these drugs consistently may already be partially sedated and that excessive sedation might result if too large a dose were administered. Also to be remembered is the fact that a few people may have a history of barbiturate reactions which would contraindicate their use (Fig. 1).

Ataraxics

In recent years the ataractic (tranquilizing) drugs have come into wide usage. Medication with this group of drugs may have important considerations in dentistry. Probably the three currently most widely

used members of this group are the Rauwolfia alkaloids (Reserpine, Serpasil, etc.), chlorpromazine (Thorazine, Largactil), and meprobamate (Miltown, Equanil). Although the ataractic drugs are theoretically supposed to be effective without great central depression, a certain number of patients show varying degrees of drowsiness. In one series of 412 patients treated with chlorpromazine, 47 per cent were reported to show some tendency to go to sleep, while 23 per cent became dizzy and 19 per cent became hypotensive. These same effects

Fig. 1. Stomatitis resulting from self-medication with a barbiturate in a student. The condition cleared up spontaneously when the drug was withdrawn. (From Sommer, R. F., Ostrander, F. D., and Crowley, M. C.: Clinical Endodontics. Philadelphia, W. B. Saunders Co.)

have been noted with other ataractic drugs in varying degrees. If a dentist were unaware of the fact that the patient was taking a tranquilizing drug and prescribed a barbiturate or other depressant for preoperative sedation, a profound and possibly serious central depression might follow.

A significant number of patients who take chlorpromazine for an extended period become jaundiced. This symptom has been reported to occur even some time after cessation of therapy. As in other types of jaundice, bleeding and coagulation time is increased and any form of surgery might result in postoperative hemorrhage.

As reported above, many patients taking chlorpromazine become hypotensive. Furthermore, instead of combating the hypotension, injection of epinephrine is liable to aggravate it. For this reason epi-

nephrine-containing local anesthetic solutions should not be used in a patient under treatment with chlorpromazine. Levoarterenol (Levophed) or phenylephrine (Neo-Synephrine) is to be preferred in such patients.

Occasional cases of agranulocytosis have occurred following prolonged therapy with the ataractic drugs. The dentist should be on the alert for oral lesions indicative of this condition if a patient gives a history of such extended medication.

Anticonvulsants

Anticonvulsant drugs are extensively used in the treatment of epilepsy. Perhaps the one of most significance to dentistry is diphenylhydantoin (Dilantin), which frequently produces a marked hyperplasia of the gingivae. Since it is usually not possible to discontinue medication with this agent, this hyperplasia frequently necessitates gingivectomy. Since it appears to occur less frequently in the presence of good oral hygiene, the patient should be given frequent prophylactic treatments and instructed in good personal oral hygiene. Some newer antiepileptic drugs do not cause gingival hyperplasia. One of them, primidone (Mysoline), is stated sometimes to produce pain in the gingival area and all of them have certain disadvantages in regard to cost and other side effects, so diphenylhydantoin continues to be widely used.

Any patient with a history of epilepsy, either treated or untreated, should be handled with caution in the dental office. Every effort should be made to avoid any form of emotional stimulation which might precipitate an epileptic seizure.

CARDIOVASCULAR DRUGS

It is important for the dentist to be aware of any medication with drugs for the treatment of cardiovascular disease, both from the standpoint of possible side effects from the drugs per se and in order to be aware of any possible complications occurring during dental treatment due to the disease itself.

Antihypertensive Agents

A number of drugs are now available and used for hypertension. Patients under treatment with antihypertensive agents sometimes are prone to faint easily, particularly when sudden changes in position occur, e.g., quickly arising from a partial reclining position in a dental

chair. Nausea and vomiting occur frequently in patients taking these drugs and the stress of a dental appointment might precipitate these reactions.

Amyl Nitrite and Nitroglycerin

Amyl nitrite and nitroglycerin are frequently prescribed for patients who are subject to anginal seizures. Since these drugs not only dilate the coronary vessels but other vessels as well, the resultant fall in blood pressure sometimes results in fainting. Even more significant is the fact that the stress of a dental appointment, particularly if pain were involved, might precipitate an anginal attack.

Digitalis

Digitalis and its derivatives as well as a number of newer agents are used in myocardial insufficiency (heart failure), often over prolonged periods. The digitalized patient is easily nauseated and is particularly prone to vomiting when placed under stress, e.g., a tooth extraction or even operative dentistry.

Mercurial Diuretics

In some cases of myocardial insufficiency, nephritic edema may occur and diuretics may be used to combat it. Prolonged use of mercurial diuretics has been the cause of mercurial stomatitis which is sometimes confused with ulceronecrotic gingivostomatitis (Vincent's).

Quinidine and Procaine Amide

Quinidine and procaine amide are frequently prescribed for patients with cardiac arrythmias or patients subject to paroxysmal tachycardia (intermittent periods of very rapid heart beat). Patients under such medication sometimes exhibit a very severe drop in blood pressure when under stress. They are also subject to episodes of nausea, vomiting and dizziness. These drugs are known to depress white blood cell formation, and the dentist should give careful consideration to any lesions suggestive of agranulocytosis in patients who have a history of prolonged administration of anti-arrythmic agents.

From the above brief discussion of cardiovascular drugs it seems clear that it will be necessary at times to consult with the patient's physician before formulating dental treatment plans for a patient who

gives a history of treatment with this drug group. Many times it may be necessary to delay other than emergency dental treatment for the cardiovascular patient, and in still other instances preoperative sedation and short appointments will be indicated.

Prophylaxis of Subacute Bacterial Endocarditis

Though not strictly within the scope of this article, while discussing the cardiovascular patient it seems advisable to emphasize the dentist's responsibility in prevention of subacute bacterial endocarditis. Whenever a patient gives a history of acute rheumatic fever, acute articular rheumatism, known valvular heart disease or congenital heart disease, prophylactic antibiotic therapy should be used prior to extractions, deep periodontal curettage or any other procedure which will open a significant number of blood vessels to the ingress of bacteria.

ANALGESIC DRUGS

It is not uncommon for patients with painful dental conditions to delay coming to the dentist for days or weeks with the hope that they will experience a spontaneous remission of their pain. During this time they frequently take acetylsalicylic acid (aspirin) or one of the A.P.C. formulas such as Anacin, Empirin, Acetidine or other proprietaries which contain aspirin. This is of significance when extractions or other dental surgery is contemplated because the taking of aspirin over a period of days or weeks may produce a hypoprothrombinemia (low prothrombin level) with increased coagulation time. This, of course, increases the possibility of postoperative hemorrhage. In the case of patients who have a history of taking aspirin constantly over a period of time, appropriate tests should be run to determine whether blood clotting is normal. If it is not, the condition can usually be corrected by preoperative medication with a vitamin K substance such as menadione sodium bisulfite, U.S.P. The usual adult dosage is 5 mg. daily for 4 to 7 days prior to surgical procedures.

When a dentist is contemplating the use of analgesic agents, a past history of the patient's experience with these drugs is helpful. For example, a few people are seriously allergic to aspirin and even therapeutic dosages may cause severe reactions. Angioneurotic edema, severe asthmatic attacks, urticaria and other severe or unpleasant reactions have been reported in such patients. While most patients can take codeine without difficulty, some individuals consistently become nauseated when they attempt to take it. Some patients become exces-

sively depressed when given meperidine (Demerol), and severe nausea has followed the administration of methadone in certain individuals.

DRUGS FOR THE CONTROL OF HYPOTHYROIDISM AND HYPERTHYROIDISM

Thyroid Substances

In cases of hypothyroidism, desiccated thyroid substance (thyroid U.S.P.) is most frequently used, although recently two synthetics, sodium levothyroxine (thyroxine) and sodium biothyronine, have replaced it to a very limited extent. The principal evidences of overdosage with thyroid substances are rapid pulse, palpitation, dyspnea, hyperactivity, sleeplessness, excessive warmth, dizziness and gastrointestinal disturbances. A patient known to be taking thyroid substances and exhibiting some or all of these symptoms would not be a good risk for any dental procedure. The patient taking thyroid substance, even in normal therapeutic doses, often has a low tolerance for opiates. Generally speaking, it is well to use nonopiate analgesics in such patients; if opiates are considered essential, they should be given in conservative doses.

Thiouracil

Many cases of hyperthyroidism are now treated therapeutically with a drug known as thiouracil. Cases of parotitis and agranulocytosis have been reported from this drug, and oral lesions suggestive of agranulocytosis would indicate a differential blood count.

Any patient with known hyperthyroidism, whether under treatment or not, is a poor risk for extensive dental treatment. Any undue stress may provoke a thyroid crisis. Therefore, it is well to discuss any proposed extensive dental treatment with the patient's physician before it is undertaken.

INSULIN AND DIABETES

It a patient gives a history of taking insulin it usually means that he is diabetic and therefore more of a risk for intraoral surgical procedures than the normal patient. In most instances it is wise to consult the diabetic patient's physician before carrying out even such minor procedures as tooth extraction. In some instances the physician will

give approval for such procedures with little risk involved if the patient's insulin dosage and dietary regime are well controlled. In other instances it may be necessary to take extensive precautions, including hospitalization, even for minor surgical procedures.

In any case it should be remembered that emotional stress tends to increase the blood sugar, and in a diabetic this may be serious. Diabetic coma has been reported following extractions. Usually a diabetic patient should be given preoperative sedation to reduce his apprehension. A good psychological approach should be used by the dentist to increase the confidence of the patient. It is unwise to use high concentrations of epinephrine in local anesthetic solutions, both because of the local ischemia and because the absorption of epinephrine tends to increase the blood sugar level. It should also be remembered that general anesthetics tend to increase the blood sugar level and that special precautions in their use are necessary with the diabetic patient.

It is highly important for the dentist to be aware of diabetes in his patient and to obtain the necessary medical advice and observe the suggested precautions before attempting even minor oral surgery. In addition to the danger of precipitating a diabetic coma, serious postoperative infections may occur in the diabetic patient who is not under proper treatment. Certainly no surgery should be contemplated in uncontrolled diabetes.

DRUGS FOR CONTROLLING ALLERGY

While a number of different agents are used for the control of allergy, the antihistaminic drugs are undoubtedly most frequently used and probably of most significance to the dentist. Diphenhydramine (Benadryl) hydrochloride and tripelennamine (Pyribenzamine) hydrochloride as well as other antihistamines may be given to a patient for weeks at a time. In such instances they frequently produce considerable central depression and it would be unwise to superimpose further sedation (e.g., a barbiturate) prior to dental appointments. It has also been suggested that patients under treatment with these drugs might not show the usual clinical signs of infection. Certainly the anti-inflammatory action of the antihistamines needs further study before this effect or their value in control of postoperative inflammation can be properly evaluated.

In some types of allergy, ephedrine and aminophylline are extensively used. These drugs are central nervous system stimulants and a patient being treated with them may be unusually nervous during dental appointments. It may take larger than usual dosages of barbiturates or other sedatives to control nervousness of this type.

The fact that a patient is suffering from allergies to the extent that medication with any of the above drugs is necessary is also of considerable significance to the dentist. Such patients are more liable to show sensitivity to penicillin and other antibiotics, and to local anesthetics and other drugs used in dentistry.

CENTRAL NERVOUS SYSTEM STIMULANTS

Many patients take certain central nervous system stimulants from time to time to counteract minor states of mental depression or to maintain alertness when it is necessary to work long hours without sleep. Certain drugs which are given to decrease appetite are also C.N.S. stimulants. The most widely used agent of this group is amphetamine (Benzedrine), but salts of dextro-amphetamine (Dexedrine) and methamphetamine (desoxyephedrine) are also widely used. Salts of the latter are known by a number of trade names including Desoxyn, Amphedroxyn, Desyphed, Dexoval, Doxyfed, Efroxine, Norodin, Semoxydrine and Syndrox.

The principal significance to dentistry is that patients who have been taking these drugs often exhibit excessive nervousness and much larger doses of barbiturates or other sedatives are necessary for effective preoperative sedation. Unless the patient's physician feels that continuous medication of this type is essential, it would be wise to have the patient discontinue the use of central stimulants during the course of dental treatments.

DRUGS USED IN THE TREATMENT OF GASTRIC ULCER

Methantheline (Banthine) bromide, propantheline (Pro-Banthine) bromide, atropine, belladonna and a number of other drugs are sometimes used for the treatment of gastric or duodenal ulcer. All of them produce varying degrees of xerostomia (dryness of the mouth) as one of several side effects. Occasionally dentists have been consulted in regard to the dry mouth when the action of the drug has been inadequately explained by the physician. It is obviously important for the dentist to recognize the source of the xerostomia. A history of an active ulcer might also indicate delay of extensive dental procedures until the ulcer is under control.

Atropine sulfate has long been used as an antisialogogue in dentistry for control of excessive salivation. Recently methantheline (Banthine) bromide has come into extensive use for this purpose and appears to produce more rapid and effective control of salivation. The usual adult dose is 100 mg., 30 minutes to one hour before the appointment.

ANTILEUKEMIC DRUGS

Several drugs are now being employed for the palliative treatment of some types of leukemia. Busulfan (Myleran), mercaptopurine (Purinethol) and mechlorethamine (nitrogen mustard) are common examples. The greatest significance of these drugs probably lies in the disease itself; the dangers of extractions or other surgical procedures in the leukemic patient are well known. Some cases of agranulocytosis following the use of these drugs have been reported. Both the leukemia itself and agranulocytosis may produce a lowered resistance in the gingival tissues, with evidence of localized infection.

DISCUSSION

While the above groups of drugs do not constitute an exhaustive coverage of systemic drugs which may have significance to the dentist, they are the most commonly used drugs which may indicate changes in dental procedures or unusual precautions in treating the patients taking medication. Certainly these many possible complications from systemic drug therapy emphasize the necessity of taking a history and of inquiring into the patient's current or past experience with drugs before undertaking extensive dental treatment. The knowledge thus gained often may help the dentist avoid serious complications and might even save the patient's life.

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The Microbiology of the Oral Cavity and Its Systemic Significance

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The oral cavity of man is densely populated with microorganisms throughout his life time. Many of the microbes are capable of producing disease. Yet most of the time the individual may be in "good health." Under these conditions man is said to be adapted† to his oral microorganisms, and they in turn, as demonstrated by their flourishing growth, are adapted to their environment. Thus, under normal conditions a healthy balance exists between the microorganisms and the host tissue. This interdependence between the host and his oral microbiota (the sum total of regional microbic populations) is very apparent when the healthy balance of adaptation is disturbed. Disease, local or systemic, is characterized by changes in the reactivity of the host on the one hand and in either the composition or the "aggressiveness" of his oral microbiota on the other hand.

THE ORAL MICROBIOTA IN THE HEALTHY ORGANISM

The mouth is sterile before birth but soon becomes contaminated. During passage through the birth canal, the mouth of the infant acquires bacterial and perhaps fungal, viral, and protozoal organisms. Shortly afterward, his mouth acquires additional microorganisms from the skin, the mouth and the upper respiratory passages of persons in the immediate environment. Within a few days the types of microorganisms in the infant's mouth become almost as numerous as later in life. Only the spirochetes and some of their anaerobic associates remain absent until the teeth erupt.

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† Webster's Collegiate Dictionary defines adaptation as "Modification of an animal or plant (or of its parts or organs) fitting it more perfectly for existence under the conditions of its environment." As used in this essay, adaptation is considered a continuous process rather than a defined state.

Although many factors may change the composition of the oral microbiota, certain organisms appear to be common inhabitants of human mouths. These are termed "indigenous," or "resident." Other forms which occur in the mouth only occasionally are considered "transient," or "adventitious."

Prominent among the *resident* microorganisms are non-hemolytic or viridans streptococci; gram-negative anaerobic cocci called veillonellae; fusobacteria, which, together with a variety of motile spirochetes and vibrios, constitute the so-called fusospirochetal complex; and diphtheroids. Also occurring with fair regularity but in smaller numbers are some micrococci (including *Staphylococcus albus*), enterococci and other serologically distinct streptococci, neisseriae, lactobacilli, bacteroides, actinomycetes (ray fungus), the yeast-like Candida, the herpes simplex virus, and two types of protozoa.

Among the more frequently found *transient* microorganisms are intestinal coliform rods, spore-bearing bacilli derived from soil and air, and the following pathogens: clostridia of tetanus and gas gangrene; beta hemolytic streptococci, commonly responsible for tonsillitis and other acute diseases; pneumococci, which are able to produce pneumonia; *Staphylococcus aureus*, which is implicated in the pathogenesis of boils and food poisoning; *Neisseria intracellularis*, which may cause epidemic meningitis; and *Hemophilus influenzae*, which may produce meningitis in children. This listing is not intended to be complete. It takes into account only those among the typical microorganisms which have been classified and does not mention the numerous pathogens which may happen to be present in the "healthy" oral cavity before or after causing disease.

In spite of certain difficulties in obtaining accurate data on the quantitative distribution of the oral microbiota, it may be said that the microbiota in any mouth tends to remain constant quantitatively as well as qualitatively. It undergoes temporary alterations during daily activities after which it soon regains its regular characteristics. For example, during sleep the numbers of bacteria increase, whereas eating and toothbrushing cause a rapid temporary drop in bacterial numbers. The microbiota of a given individual also undergoes permanent changes. These may be related to such factors as the age, nutrition, and general health of the individual, or the presence of teeth.

It may seem curious that adventitious microorganisms are denied permanent residence in the oral cavity and that transient pathogens are not more frequently allowed to cause disease. Part of the answer may lie with immune substances produced by the host in response to microbial influences. A growth inhibition which may be exerted by the well adapted indigenous microorganisms against bacterial and prob-

ably also viral intruders may be yet another answer. The predominant metabolic pathways in a well cared for healthy mouth seem to favor an optimal ecologic balance among the oral microbiota. There are experimental indications that this equilibrium may be of *systemic significance* in the maintenance of general health of the human host.

Suppression and Superinfection

If a healthy equilibrium among the oral bicrobiota is necessary to good health, then a general suppression of this microbiota or a disturbance of its equilibrium is undesirable. It seems fortunate that cosmetic preparations claimed to disinfect the mouth are incapable of killing bacteria wholesale, for the accomplishment of this aim would weaken the oral defenses against disease. There would be no microorganisms available to stimulate the production of antibodies and to produce metabolites unfavorable to adventitious pathogens. Even a partial sterilization carries marked disadvantages unless it is confined to a small area. An example of this may be seen in the effects of the modern antibiotic medicines. They cannot be directed at chosen microbial targets and usually kill or inhibit first the potentially beneficial streptococci and lactobacilli. It makes little difference in this respect whether antibiotics are applied topically, in the form of lozenges, packs, ointments, dentifrices, and dental cones, or systemically over extended periods of time. With one large part of the microbiota out of the way, other species, which under normal conditions are held in check, are permitted to overgrow. They outgrow the rest because they are more resistant to the effects of antibiotics. Among these species are enterococci, *Staphylococcus aureus*, gram-negative enteric bacteria, and the fungus Candida. It seems that the broader the antimicrobial spectrum of the drug employed, the more far reaching is the disturbance of the bacterial balance of power. With the increasing use of antibiotic preparations, the diseases due to superinfection by drug-resistant bacteria have increased far beyond past experience. As an example, one may name *thrush* (moniliasis), which is caused by *Candida albicans*. It formerly was a localized disease of the oral mucous membranes in infants and the very aged, but the present-day indiscriminate use of antibiotics, particularly of the broad spectrum type, has eliminated the age preference of oral thrush and has brought about, in a number of instances, the systemic spread of moniliasis to the intestines and the lungs. One wonders to what extent antiseptics commonly incorporated into mouthwashes and dentifrices may produce untoward effects by suppressing the best adapted, and therefore least pathogenic, microorganisms.

An interesting illustration of man's interference with a natural ecologic balance is related in *Life*, December 9, 1957:

"Years ago Lake Apopka in central Florida was well populated with game fish like bass and perch which ate well on a small bony fish, the gizzard shad. But in the past few years the shad multiplied much faster than the game fish could eat them and they began to crowd the bass and perch out of the lake.

"Last month Florida's Game and Fresh Water Fish Commission embarked on a mammoth shad-killing operation. They poisoned the 48-square-mile lake with rotenone, which constricts fish gills. Within 48 hours over 3.5 million pounds of dead shad rose to the surface. Most of the bigger game fish, which have higher tolerance of the poison, survived. Local residents were oppressed by the odor of dead fish that hung in the air but pleased at the prospect of being able to fish again in their lake."

THE ORAL MICROBIOTA IN THE SICK ORGANISM

The adaptive balance may be altered not only by primary changes in the microbiota, but also when the tissues of the host are changed either by various forms of trauma or by increased catabolism accompanying old age or disease. Even *acute* systemic disease may influence the host-parasite equilibrium. For example, in a patient afflicted by the common cold the composition of his throat flora is changed to a predominance of beta hemolytic streptococci, pneumococci and *Staphylococcus aureus*. Any of these pathogens may occur in almost pure culture or mixed. *Hemophilus influenzae* also increases in numbers under the influence of the common cold, and there may be a preponderance of the more pathogenic capsulated form over the commonly present unencapsulated Hemophilus strains.

A similar bacterial change is the increase of hemolytic streptococci in the mouth during streptococcal pharyngitis or tonsillitis. Also, herpetic fever blisters are a well known oral indicator of a head cold. The herpes simplex virus is considered by many to be indigenous to the oral cavity. It may cause herpetic gingivostomatitis in children before they acquire immunity and it then may lie dormant until the immune balance is disturbed by a common cold or a gastrointestinal or other upset. Then the typical vesicles appear. Only rarely does this virus overcome the host resistance to the extent of causing a major systemic disease such as meningoencephalitis. Flare-ups of herpetic infection in adults constitute one example of *endogenous infection*, an infection caused by an indigenous microorganism and therefore not contagious among people possessing a comparable oral microbiota.

Changes in the oral microbiota also occur when tissue resistance is lowered by *chronic* malnutrition or debilitation. For instance, in cases of anemia, leukemia or other blood diseases, one may find mucosal ulcers settled with *Candida albicans*. In extreme cachexia the fusospirochetal complex may produce gangrene (noma) of a cheek. In spite of the fact that the primary damage in these lesions is noninfective, antimicrobial therapy is often curative.

In the infirm bed patient, prolonged mouthbreathing is frequent and accompanied by proliferation of oral microorganisms. Aside from causing the uncomfortable sensation of parched mucous membranes, this condition presents an increased opportunity for tremendous numbers of bacteria to be aspirated. Aspiration may lead to *pneumonia*, particularly after surgical anesthesia and in aged or debilitated bed patients. In these cases good *oral hygiene* care may help prevent untoward systemic sequelae. Oral hygiene is equally important in patients suffering from tuberculosis of the lungs or from neoplasms in the respiratory or upper gastrointestinal passages, for a secondary (endogenous) infection of these lesions may retard their healing and seriously jeopardize the recovery of the patient.

THE MICROBIOTA IN ORAL DISEASE

Infective surface lesions in the mouth are very frequent. Most of the defects of the tooth surface are due to dental caries; those of the mucosa stem from a variety of causes. The strictly microbial causes are usually exogenous. Local endogenous infections, on the other hand, are usually traceable to events in the human host, which tend to lower the level of adaptation in the tissue cells of the oral mucosa. Therefore, the indigenous microorganisms may usually be regarded as secondary opportunistic invaders rather than as the "cause" of oral soft tissue lesions.

Exogenous Infections

When the oral cavity is the primary seat of a specific exogenous infection, the causative pathogens are usually present in the oral lesions. Among the bacterial diseases one may name diphtheria, tuberculosis and syphilis. Primary lesions of *diphtheria* usually occur in the throat, very rarely in the oral cavity proper. Those of tuberculosis are usually found in the lungs. Primary lesions of *tuberculosis* in the mouth are extremely rare, whereas secondary (postpneumonic) tuberculous ulcers occasionally occur on the alveolar processes. *Syphilis*, on the other hand, frequently becomes manifest first in the mouth or throat. The

causative organism is difficult to demonstrate because indigenous spirochetes are always present.

Among fungal diseases, *histoplasmosis,* which affects mainly the reticuloendothelial system, may have its primary ulcerative lesions in the oral cavity. Two viral diseases, *herpangina* and *foot and mouth disease,* characteristically affect mainly the oral and pharyngeal mucous membranes. The former disease is mild and self-limiting, the latter rarely fatal.

Endogenous Infections

Much more frequent are those oral diseases in which the infective component is nonspecific, indigenous. The resident microorganisms thrive on all mucous membrane *lesions* whether they be of traumatic (thermal, chemical, actinic, etc.), nutritional (hypovitaminotic), hematologic, dermatologic or oncologic (neoplastic) character. Little is known of the quantitative or qualitative changes among the indigenous microorganisms in the presence of any of these oral diseases: Sometimes there is an apparently general microbial proliferation, at other times the numerical increase may be limited to certain types of microbes. Occasionally, the finding of acid-fast rods or the numerical predominance of certain forms (e.g., *Candida albicans;* fusospirochetal complex) may aid in arriving at a diagnosis, but in general the bacteriologic smear technique is of limited value in differentiating between oral lesions. In "bacteriologic biopsy" of surgical lesions it is essential that only the deepest layers of the lesion be sampled. Even then, only a pure culture or a prevalence of clinically important bacterial species is of diagnostic value.

The two most prevalent oral diseases and those with which the dentist is most intimately concerned are caries and gingivitis. Their infective components, too, are indigenous.

Periodontal Disease. The periodontal tissues are affected by local conditions of irritation, tooth alignment and the distribution of the physical load and are also a very sensitive index of the state of homeostasis of the entire organism. It is often possible to infer from the appearance of the gingival tissue a general state of stress (of whatever somatic or psychologic nature), nutritional or endocrine imbalance, the use of various drugs, or contact with allergens, industrial fumes or metallic poisons.

Gingival calculus is the most common local irritant. Its organic matrix contains a variety of oral microorganisms including streptococci, staphylococci, lactobacilli and the filamentous actinomycetes, nocardiae and probably leptotrichiae. Host cells of surface and blood

origin also participate in the formation of the matrix. At a later stage the matrix is permeated by calcium carbonate and magnesium phosphate so that ultimately three-fourths of the structure is crystallized. Whereas its bacterial attachment is anchored in microscopic recesses of the tooth surface and may damage the cementum, the rough crystalline spicules of calculus erode the epithelial lining of the gingival crevice. The presence of the oral microbiota assures continuous contamination of the shallow gingival ulcers, promotes spread of infection into deeper tissue layers and contributes to the extension of periodontal disease.

In most cases the fusospirochetal components of the oral microbiota proliferate in response to the altered tissue adaptation which, in turn, is due to local and/or systemic disturbances. The bacterial picture seems to be qualitatively identical in acute marginal gingivitis, necrotizing gingivitis (Vincent's disease) and complex periodontitis. Viral causation of periodontal disease seems unlikely. The infective component is rarely if ever the prime agent in periodontal disease but it is never absent and may help to modify the character of the disease. The part it plays is evidenced by the response of the disease to effective antiseptic medication. It may also become evident by such systemic effects as the swelling of regional lymph glands, malaise and fever which indicate spread of infection or its products beyond the oral cavity proper.

Dental Caries. The initial lesion of dental caries probably requires decalcification by acid, whereas later stages in the carious process may be attributed to a combination of demineralizing and proteolytic agencies. Accordingly there may be many indigenous types of microorganisms capable of attacking the hard substances of the tooth. The fact that dental caries cannot be produced in germ-free animals definitely establishes the contribution of microorganisms to this disease. In addition, a wide variety of physical and chemical factors inherent partly in the host and partly in his nutrients seem to participate in the pathogenesis of dental caries.

The disease usually attacks the tooth at those parts of its surface at which bacteria are permitted to accumulate. These accumulations, the so-called *dental plaques,* are thin, adherent films consisting of filamentous, bacillary and coccal forms—members of the resident oral microbiota. As the carious lesion progresses into the dentin, there are always a few tubules that contain cocci at a level far ahead of actual decalcification and decay. Because these advanced microorganisms cannot be reached by surface disinfectants, attempts at cavity sterilization are futile.

The *dental pulp* is sometimes laid open by decay and often invaded

through a layer of macroscopically intact dentin. By reaching the pulp, the microorganisms have arrived at the lymph and blood capillary bed of the bone marrow. They have left their habitat, the oral cavity, and have invaded the host organism itself. Another stage is set, similar to the one in periodontal disease, for systemic endogenous infection.

THE ORAL MICROBIOTA OUTSIDE ITS HABITAT

The adaptation of the host to his regional indigenous microorganisms seems to be accomplished preeminently in the superficial cells of the corresponding regional tissue. When the barrier is penetrated or bypassed, as in progressive periodontal disease, perforating dental caries or some other forms of trauma, the interplay of infection reaches unadapted tissues. These may be either contiguous, when the infection spreads by extension, or remote, when infective material is transmitted by way of experiment or accident or is disseminated via the lymph and blood streams. Thus the various infections arising from the oral cavity may be conveniently grouped according to the mode of transmission of the infective agent.

Transmission by Extension

The healthy dental pulp and the sound periapical tissues are usually sterile. The inflamed, dying or dead pulp and the inflamed pericementum are usually infected. Any members of the indigenous oral microbiota may be found in these locations. Viridans streptococci have been reported most frequently, but more resistant organisms, such as enterococci or *Candida albicans*, have often been recovered. Usually they occur in mixed cultures more or less representative of the oral microbiota whence they are commonly derived by extension of the carious process. However, one cannot be sure that all of the organisms stem from the oral cavity. A process known as *anachoresis* operates in inflamed tissues to attract and fix bacteria which happen to pass by in the blood stream. This may explain how typhoid bacilli and other bacteria responsible for diseases in which dissemination into the blood stream occurs come to colonize the dental pulp or the periapical tissues. Similarly, typical inhabitants of the gingival crevice are often found in necrotic pulps of non-carious teeth which were devitalized by mechanical trauma without injury to the surface.

Another transmission by contiguity occurs in cervicofacial *actinomycosis*, a suppurative disease of the submucous soft and hard tissues in which the causative organism is found in mixed culture with a variety of other indigenous oral microorganisms. Although the cause

of tissue invasion by this mixed flora is not known, actinomycosis is now definitely classed among the endogenous infections.

In suppurative *osteomyelitis* of the jaws, which may be caused by a variety of agents but is most frequently due to staphylococcal infection of the bone marrow, the staphylococci usually enter the tissues through an infected root canal or through an extraction wound. Pathogenicity of staphylococci in the oral cavity itself has not been reported. Teeth and tooth sockets have also been found to serve as occasional portals of entry for such specific (exogenous) diseases as tetanus, tuberculosis and poliomyelitis.

Accidental Transmission

Human bite injuries or injuries to knuckles striking against teeth result in the implantation of the fusospirochetal complex into subcutaneous or articular tissues with ensuing necrotizing inflammation and, occasionally, generalized sepsis.

Experimental Transmission

When the fusospirochetal components of the oral microbiota are introduced into the mouth of a healthy animal they remain harmless. When the same components are injected into the groin of a guinea pig they produce large necrotizing abscesses.

Viridans streptococci are nonpathogenic in the oral cavity and are always present in large numbers. When injected repeatedly into the veins of rabbits or dogs, cultures of these same microorganisms are capable of inducing a fatal disease similar to human subacute bacterial endocarditis.

Circulatory Transmission

The dissemination of the oral microbiota throughout the organism via the blood stream has been implicated in diseases of the heart, kidneys, eyes, joints, nerves, etc. Although the evidence for this type of disease causation is more circumstantial than direct, the amount of work done on this subject is so large that the following two sections will be devoted to a discussion of surgical and non-surgical causes of systemic blood-borne infections of oral origin.

SURGICAL BACTEREMIA

The presence of bacteria in the blood stream constitutes bacteremia. This may occur spontaneously as, for instance, when proliferating

microorganisms reach the lumen of a capillary in pulpal or periodontal tissue and are carried away by the blood. *Spontaneous* asymptomatic bacteremia is detected very rarely, partly because the bacteria are usually rapidly eliminated.

Positive blood cultures are demonstrable with very much greater frequency immediately following *surgical* operations. They have been reported after abdominal and orthopedic surgery, after minor genitourinary tract operations, after tonsillectomy, and after various dental manipulations. Bacteremia may be provoked by the extraction of teeth, the preparatory luxation of teeth from their sockets, the removal of calculus by scaling, and by strenuous gingival massage. The occurrence of bacteremia from the trauma of mastication alone is questionable.

As previously mentioned, circulating bacteria may colonize inflamed tissues by *anachoresis*. Another mechanism by which bacteria may accumulate at various locales is *embolism*. In this phenomenon the narrow lumen of a capillary may obstruct the passage of a clump of bacteria, which begin to vegetate in the segment of surrounding tissue. By anachoresis or by embolism a symptomless bacteremia may give rise to some diseases of the eye (*iritis*), of the kidneys (*subacute glomerulonephritis*) and of the heart.

Subacute bacterial endocarditis (endocarditis lenta) is a low grade infection of the heart valves. Persons of all ages, whose heart valves were previously damaged by acute rheumatic fever, congenital defects, syphilis or arteriosclerosis, are considered predisposed. The disease was close to 100 per cent fatal before the advent of chemotherapeutic and antibiotic agents, and it still carries a mortality rate of 30 to 50 per cent. The wide range of predisposition and the uncertainty of cure make prevention paramount. Basic to prevention of this disease is information on bacteremia.

Among dental operations, bacteremia is seen most frequently with *tooth extraction*. This, therefore, occupies the center of interest as a possible causative factor in the development of subacute bacterial endocarditis. A survey of the literature from 1926 to 1950 reveals that among 2070 patients suffering from this disease, 217, or 10 per cent, gave a history of tooth extraction preceding the onset. This loose statistical association supports the assumption that tooth extraction and infective endocarditis are etiologically connected. Other supportive facts are: tooth extraction is very frequently accompanied by bacteremia, heart valves may become infected in the process of bacteremia, and bacteria isolated from blood after tooth extraction resemble bacteria isolated from blood of patients with subacute bacterial endocarditis. Viridans and other streptococci, which have always received first recognition among the oral microbiota, are incriminated in the

vast majority of cases of subacute bacterial endocarditis and similarly predominate among bacteria identified from blood cultures accompanying tooth extractions. Almost any microorganism of low virulence and pathogenicity has occasionally been isolated from the blood of patients suffering from endocarditis. Some of the bacteria, lactobacilli and veillonellae, for instance, are less likely to be derived from sources other than the oral cavity. With improved techniques an increasing variety of organisms probably originating from the mouth is being identified in postextraction blood cultures. For all these reasons it seems very likely that the bacteremia occurring with tooth extractions may, once in many thousands of patients, lead to infection of previously damaged heart valves.

Bacteremia seems to occur independently of general attributes of a patient (age, sex, erythrocyte sedimentation rate), of the type of anesthesia employed and of variables in oral health (vitality of teeth, periodontal health and hygienic state of the mouth). Although bacteremia may be more frequent (or more massive?) when more teeth are extracted at one time, the detectable trend seems slight. At least up to about six teeth, the number extracted seems of more academic than practical significance. A rising trend seems discernible also with prolonged duration of operation, and the two trends cannot be separated.

The entry of bacteria from the surgical wound (alveolar socket) into the blood stream probably cannot be prevented, but the effects can be reduced by systemic application of antibiotic drugs. There is a consensus that antibiotic preparations should be administered as rarely as possible. Therefore, the patient is served better if large-scale extractions are concentrated in a smaller number of operations. The often-heard advice to extract teeth singly or in twos would augment the number of operations and of antibiotic medications.

Another reason warranting the *concentration of extractions* is that the extraction of each single tooth carries a risk of bacteremia and that this risk is multiplied by repeated operations, whereas it seems to increase but little as more teeth are removed during each operation. The number of teeth to be extracted at one time may be determined by the general health of the patient and by the skill of the operator.

A third justification for extracting more rather than fewer condemned teeth is the risk of contracting subacute bacterial endocarditis. Among the case histories of patients with subacute bacterial endocarditis, 58 have been found listing the number of teeth extracted prior to the onset of the disease. Twenty-six patients had one tooth extracted, six patients had two teeth extracted, and 26 patients had more than two teeth extracted at a time. This distribu-

tion indicates that the risk of contracting the disease is no greater with the extraction of several teeth at one time than with the removal of a single tooth.

The fourth motive for a more radical approach lies in the mental and physical *stress* to which surgical operations subject the patient. Stress has become recognized as a factor in disease causation and it may be a factor in bacteremia. It would appear that the degree of stress elicited by the removal of five or six teeth is not appreciably greater than the insult inflicted by the extraction of one or two teeth.

NON-SURGICAL SYSTEMIC EFFECTS OF LOCAL INFECTIONS

The understanding of many pathologic processes is greatly enhanced by recognition of the distinction between the two forms of bacteremia. Surgical, or provoked, bacteremia is transient (of relatively short duration) and it is occasioned by the manipulation of organs such as teeth or periodontal tissues. These tissues themselves may be either healthy or diseased. In contrast, spontaneous, or unprovoked, bacteremia may be transient, continuous or intermittent, and it originates without the need of outside interference *from infected tissues only*. In the latter case, infection is transmitted via the blood stream from one primary localization to other more or less remote organs where it may give rise to secondary or metastatic infection. Thus, a kidney infection may (in the absence of surgical interference, like a tooth extraction) be initiated metastatically from a tooth only if this tooth is infected.

A center of infection is a diseased portion of organic tissue engaged in metabolic interaction with infecting microorganisms. From this field of pathologic activity the lymph and blood streams carry away not only live bacteria but also products of their metabolism and products of the tissue breakdown. Many of these substances may be considered toxic to the host organism. Their dissemination through the blood stream constitutes *toxemia*. In some diseases such as diphtheria or tetanus the toxins produced by the specific organisms are carried to remote parts (heart muscle, central nervous system) to elicit severe reactions in organs not reached by the bacterial bodies themselves. It is very likely, though not proven experimentally, that the substances produced by the oral indigenous microbes in the disintegration of periodontal, pulpal or periapical tissues may in the long run adversely affect the healthy functioning of a joint or of a sciatic nerve or the normal progress of healing of a wound. No organ in the body can be assumed to be exempt from the influences exerted by centers or "foci" of infection which disseminate either bacteria or toxins.

The poisons diffusing from chronic infections may sometimes sensitize the organism or any of its parts to an *allergic* response. It has not been determined whether such a process may ultimately lead to arthritis, neuritis and other diseases often claimed to be of focal origin, but skin reactions have been produced experimentally in response to allergens isolated from diseased pulps. Another disease mechanism is postulated by the *neurotrophic* theory, which explains the transmission of ill effects from a focus of infection to an effector organ via nervous rather than circulatory pathways. Lastly, the effect of a chronic localized infection on the production of disease in distant organs or in the entire organism may be explainable by maladaptation resulting from chronic *stress*. Just as resistance of the organism or its parts may be frittered away by lack of sleep, malnutrition or repeated or chronic diseases, so a weakening of host adaptation may be brought about by the chronic influence of hidden foci. The stress mechanism is often adduced in explaining the pathogenesis of arthritis, bursitis, myositis, and similar ill-understood conditions.

The primary seat of focal infections can be demonstrated relatively easily in *acute* diseases, particularly in those in which the causative microorganisms themselves are disseminated. One may think, for instance, of miliary tuberculosis originating from a focus in the lungs or of an osteomyelitis from a distant furuncle. The causal connection between acute rheumatic fever and a preceding acute tonsillitis or acute pulpitis is highly suggestive, although no bacteria can be detected in the joint lesions.

The connection between ill-defined disease states and *chronic* primary infections may become so obscure as to reduce the diagnostician to speculation rather than to interpretation of evidence. However, such speculation about the primary focus of infection should not deviate from the rules of common sense. There is no reason to hypothesize that the pulp of an intact vital tooth, or firm, pink gingival tissues, or a deeply impacted molar may be the origin of infection for a myocarditis when obviously these oral tissues are free from infection. *Bacteriologic* tracking is of little avail, since infections of the dental and supporting tissues are notoriously nonspecific (endogenous). *Roentgenographic* evidence is of little help, because in radiolucent chronic abscesses, granulomas and cysts the infection is walled off and does not readily diffuse. In acute inflammation (which is not demonstrable by means of x-rays), diffusion is hampered by intense phagocytic activity. The most likely *intradental* foci are the asymptomatic, x-ray negative, chronic infections of pulps and periapical marrow spaces of primary and permanent teeth. It matters little whether they were originally contaminated through a deep carious cavity or by anachoresis follow-

ing trauma. Chronic local irritants of the *periodontium* such as gingival calculus, sharp margins of cervical cavities, overhanging fillings, crowns, and other dental restorations or appliances produce a large wound surface. One would logically assume that from an infected wound bacteria or toxic products are continuously fed into the organism.

It has been shown that children may improve subjectively and may appreciably gain in weight and development after the removal of chronically infected teeth. Yet in general the establishment of *evidence* for the connection between chronic primary infections and systemic sequelae is frustrated by a large number of problems which have not been solved. Recent experiments demonstrated that substances produced by the microbiota of the human gingival crevice are not toxic for guinea pigs. Direct diagnostic methods for the detection of foci are unreliable. The onset of systemic effects is usually gradual and the primary infections usually inapparent. It is fallacious to think that removal of the focus would be "the proof of the pudding." If the *extraction* of an infected tooth relieves a painful arthritis, it may be that the tooth was the original focus. However, the benefit may also be due either to a placebo effect (psychogenic?) or to a nonspecific shock or alarm reaction caused by the extraction, which may have stimulated the adrenal glands to an increased and therapeutically effective secretion of cortical hormones. If, on the other hand, the tooth extraction does not alleviate the pain of the arthritis, the tooth may still have been the primary seat of the culpable infection, but secondary (metastatic) infections established elsewhere may have taken over the supply of bacteria or toxins so that the primary focus has become expendable for the maintenance of the disease. Also, the anatomic changes which have developed in the arthritis may have become irreversible and self-perpetuating, independent of the poisons that caused them.

CONCLUSIONS CONCERNING PREVENTION

Although definitive proof for far-reaching systemic influences by oral foci has not been established, it must be borne in mind that there is no evidence invalidating the concept of focal infection and that it is supported by analogies in the general field of pathology. Professional common sense therefore should guide the practitioner in seeking out and removing such potential foci of infection as gingival calculus, overhanging restorations, deep periodontal pockets, deep carious cavities, devitalized teeth, and residual roots.

More important than the attempt to repair a local condition, the systemic damage of which may have become irreparable, is the pre-

vention of focal infection. This can be accomplished by recognizing periodontal and carious lesions at early stages and rendering the best kind of dental treatment known. *Early treatment* includes prevention and correction of malalignment, which is likely to contribute to the causation of dental caries and periodontal disease. It also includes any available preventive steps such as topical or systemic fluoridation. Additional policies of *hygiene* also indicated are balanced nutrition and adequate rest, particularly for the young. All these measures help to maintain a healthy balance between the host and his oral microbiota and thereby aid in the prevention of endogenous systemic infections.

Another point to remember in the conservation of the proper adaptive balance is to avoid the use of antibiotic and other antiseptic drugs except in those cases in which a strict indication may be established. The application of *antiseptics* has its place in the preparation of a sterile field for anesthetic injections, surgical operations, endodontic manipulations or in the treatment of mucosal ulcerations. It is not recommended for toilet use.

Among cases requiring *antibiotic medication* may be included endogenous infections (e.g., spreading fusospirochetoses, moniliasis, actinomycosis) in debilitated patients. In these the medicines are used as a crutch to substitute for the lack of defensive powers. Antibiotics may also be used to protect certain categories of patients against the possible effects of surgical bacteremia. Patients among whom the danger of serious consequences from bacteremia is potentially greater than average are persons with acute rheumatic fever or history thereof, patients with valvular heart disease, those suffering from diabetes mellitus, patients on prolonged treatment with adrenocorticoids, and also, possibly, persons for whom a large number of teeth are to be extracted at one time. The dosage should be high in order that the blood concentrations of antibiotics may be sufficient to dispose of more resistant bacteria, and it should be continued after operation to insure disposal of a bacteremia that may have defied premedication. The following types of medication may be considered adequate: (*a*) penicillin, administered intramuscularly in doses of not less than 300,000 units aqueous with or without the addition of procaine penicillin 30 minutes to one hour prior to operation and repeated six to 12 hours later; (*b*) penicillin V (phenoxymethyl penicillin) administered orally in doses of two tablets of 200,000 units each, not less than one hour and not over two hours prior to operation and repeated once in the course of the day; and (*c*) in patients for whom penicillin is contraindicated, erythromycin or one of the tetracyclines administered in doses totalling 1.5 to 2 grams divided over 24 hours before operation and continued in equal doses for at least 24 hours thereafter.

Space does not permit giving credit to the numerous investigators whose researches have influenced the author's views. Their contributions are gratefully acknowledged. In addition, the kindest thanks are expressed to Mrs. C. E. Bagley and Mrs. B. L. Rizzo for their assistance in the preparation of the manuscript, and to Dr. E. Cheraskin, Dr. J. B. Macdonald and Dr. P. S. Siegel for critical advice.

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Clinical Features of Early Malignant Growths of the Oral Cavity

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For definitive diagnosis, prognostication and classification of oral lesions, microscopic examination is usually necessary. However, since it is the clinician who first examines the mouth, his ability to distinguish the normal from the abnormal and to recognize features that suggest malignant behavior is the factor on which the welfare or the life of the patient may depend. A thorough understanding of the significant clinical features of these lesions is of importance to him; on them he must base his decision whether to treat the lesion, keep it under observation without treatment, perform a biopsy or employ other diagnostic tests. The present discussion summarizes some of the clinical features which should arouse suspicion and stimulate further investigation when they are observed.

For the sake of convenience of description, the malignant lesions may be grouped according to their location as follows: (*a*) superficial lesions, (*b*) deep lesions of soft tissue, (*c*) lesions of the jaws, and (*d*) lesions of salivary glands.

SUPERFICIAL LESIONS

Squamous Cell Carcinoma

Squamous cell carcinoma is the most important of the superficial malignant lesions, because it is the commonest malignant oral tumor (90 per cent) and its superficial and visible location permits early diagnosis and treatment.

Location and Incidence. Squamous cell carcinoma has been esti-

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mated to occur more frequently on the lips than intraorally, to be much more common in males than in females and to reach its highest incidence after the fourth decade. Of the lip tumors, about 95 per cent occur on the lower lip, and these usually are seen on either side of the midline. The midline and the commissures are rare sites of involvement. It is of interest to note that the lesions of primary extragenital syphilis, which are most frequent on the lips and may resemble some carcinomas, have a predilection for the upper rather than the lower lip.

Intraoral squamous cell carcinomas are usually located on the tongue, where slightly more than 50 per cent occur. Less common sites are the alveolar mucosa, palate, floor of the mouth and buccal mucosa, which

TABLE 1. *Initial Clinical Features of Carcinoma of Lip*

CLINICAL FEATURE	NUMBER	PER CENT
Ulcer	227	28.6
Wart	141	17.8
Sore	130	16.4
Scab	87	11.0
Blister	63	8.0
Fissure	62	8.0
Scale	23	3.0
Crusting	16	2.0
Sunburn	11	1.3
Tumor	9	1.1
Knot	9	1.1
Trauma, residual of	5	0.6
Other (plaque, infection, keratosis, cyst)	9	1.1
Total with information	792	100.0

are involved with about equal frequency. Tongue carcinomas arise more often on the sides and ventral surface than on the dorsum, and on the posterior two-thirds rather than the anterior one-third. The soft palate is involved slightly more frequently than the hard palate; in the floor of the mouth the anterior one-third is the more usual location.

Clinical Appearance. The clinical appearance of the squamous cell carcinoma is varied. It may present as a plaque or scale, a blister, a wart, an ulcer, a growth, or any other irregularity or abnormality of the surface or color of the mucosa (Table 1). Obviously, its clinical features in themselves are not diagnostic. A white or gray, elevated, scaly, fissured lesion of the tongue, for example, may be a benign keratosis, i.e., pachyderma oris, or evidence of cellular abnormalities on microscopic examination may qualify it as leukoplakia, or the combination of cellular abnormalities and invasion of the under-

lying tissues may identify it as squamous cell carcinoma. It is apparent, then, that keratotic lesions range from benign to early malignant forms, carry widely different prognosis and require diverse therapy. The challenge to the clinician is that of recognition of the possibilities inherent in such a lesion so that he will seek tissue analysis.

Most commonly the oral squamous cell carcinoma presents as an ulcer of varying size and depth. When small and superficial the ulcer is usually asymptomatic and is often found by accident. Such a clinical

Fig. 1.

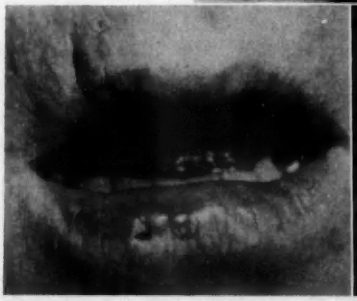

Fig. 2.

Fig. 3.

Figs. 1, 2, 3. Carcinomas of the lip—verrucous, infiltrating and ulcerative forms.

appearance for squamous cell carcinomas of the floor of the mouth is not rare, for in this location invasion occurs promptly and early recognition is of utmost importance. Biopsy should be performed on any oral ulceration, however small, which does not heal completely or almost completely within 2 to 3 weeks after the removal of any apparent cause.

Larger ulcers are almost always associated with infection, swelling and pain, and, depending on their location, they may interfere with speech or with eating. These ulcerated lesions are often described as having irregular and undermined margins. They are usually hard to palpation, i.e., are indurated. The induration in the tissues surrounding

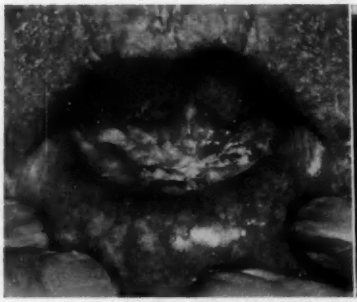

Fig. 4.

Fig. 5.

Fig. 4. Carcinoma, floor of mouth; keratotic lesion.
Fig. 5. Carcinoma, floor of mouth; ulcerated lesion.

Fig. 6.

Fig. 7.

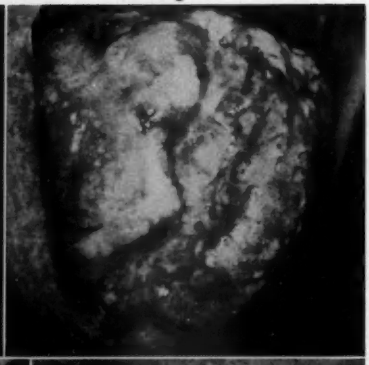

Fig. 8.

Fig. 9.

Fig. 6. Carcinoma, tongue; keratotic lesion.
Fig. 7. Carcinoma, tongue; keratotic lesion.
Fig. 8. Carcinoma, ventral surface of the tongue.
Fig. 9. Carcinoma, alveolar ridge.

the ulcer is due in part to the inflammatory exudate and in part to the infiltration of the tumor into surrounding tissue. Ulcers such as these should bring to mind not only carcinoma but lesions such as those of tuberculosis, syphilis, and other chronic granulomatous diseases. The clinical differential diagnosis would, of course, depend on the age of the patient, history, location of the lesion (e.g., an ulcer on the upper lip is more likely to be a chancre than an ulcer in the retromolar area) and the presence or absence of lesions elsewhere in the body. In any event, it is apparent that these indurated, usually infected, painful or asymptomatic ulcers of the oral mucosa should arouse considerable suspicion and warrant biopsy.

Irregularly elevated lesions of the mucosa are usually papillomas or verrucae. Under relatively rare circumstances, however, exophytic mucosal lesions which clinically resemble papillomas may, on histologic analysis, prove to be carcinomas. Such a clinical picture is particularly characteristic of a type of lesion called verrucous carcinoma which usually occurs in the old, often on the alveolar ridge.

Metastasis. In addition to evaluating the gross appearance of the squamous cell carcinoma, the clinician must search for evidence of metastasis. Lymph drainage from the lips and the oral cavity passes through one or more of the numerous nodes of the neck, the submaxillary, the submental, and the superficial, anterior and deep cervical groups. Nodes associated with the drainage of the involved area should be palpated for possible metastases. With reference to the nodes, one must remember that a palpable node is not necessarily the site of metastasis and that a lesion near the midline of the tongue, floor of the mouth or lips may metastasize to the contralateral side.

Lymphoepithelioma

Lymphoepithelioma (transitional cell carcinoma) is a rare malignant tumor of the oropharynx and the pharyngeal and lingual tonsils, areas frequently examined by the dentist. The histogenesis of this tumor is a matter of discussion, but it may be considered an anaplastic squamous cell carcinoma. It usually presents as a very small, almost insignificant, ulcer at the lateral sides of the base of the tongue or on the tonsils. It may go unnoticed and the first evidence of tumor may be a palpable cervical lymph node. Therefore, in all oral examinations, it is essential to grasp the tongue firmly and pull it out to allow a good view of the base of the tongue and the oropharyngeal and tonsillar areas. These parts should be inspected carefully for any abnormalities. Lymphoepitheliomas occur in the third and fourth decades of life and are radiosensitive tumors.

Junctional Nevus; Compound Nevus; Melanoma

Junctional nevus, compound nevus, and melanoma are rare lesions of the oral mucosa, but because of their aggressive nature they must be considered in a differential diagnosis of surface lesions. The difference between the junctional and the compound nevus is based on their microscopic features and is therefore beyond the scope of this discussion. Nevi, however, are elevated or flat, usually brown or black lesions of the mucosa. On the skin and in young patients they do not carry the same dangerous prognosis as they do when seen on the oral mucosa and in adults or old persons.

The melanoma is a highly malignant tumor that usually is seen as a non-ulcerated, deeply pigmented black lesion on the palate, lip, or gingival mucosa. In some instances ulceration may be present, but the deep pigmentation is the outstanding feature. These tumors metastasize early and are invariably fatal; thus, any solitary pigmented lesion in the oral mucosa should be looked upon with suspicion. This is not to say that all pigmented lesions are premalignant or malignant. There are a number of conditions, e.g., Addison's disease, melanosis of Riehl, Jeghers' syndrome, etc., which are benign even though pigmentation of the oral cavity may be a feature. Such pigmented lesions tend to be multiple and associated with lesions on the skin.

DEEP LESIONS OF SOFT TISSUE

Malignant tumors of deep soft tissue are rare in the oral cavity, but they do occur, and almost all known varieties of the malignant mesenchymal neoplasms have been recorded in this area. Fibrosarcoma and rhabdomyosarcomas are perhaps more frequently seen than others. Because of the rarity and the deep location of tumors of this group, no detailed clinical features and locations can be allotted to them. However, as a rule they are not freely movable; they form ill defined masses; they grow rapidly; in the early stages the mucosal surface is normal, while ulceration, infection and necrosis are later manifestations. Whereas the primary lymphomas, e.g., reticulum cell sarcoma and lymphosarcoma, have been reported in the oral cavity, the involvement of the oral mucosa in leukemia is almost constant. The first clinical manifestation of acute leukemia may be in the oral cavity; swelling is followed later by necrosis and ulceration of the gingiva, painful teeth and swelling of face and lips. Any rapidly developing generalized hyperplasia of the gingiva, with or without bleeding and cervical lymphadenopathy, should be investigated by biopsy or blood analysis.

LESIONS OF THE JAWS

Malignant tumors of the jaws, because of their deep location, are not easy to detect at an early stage. This, combined with the facts that they are highly malignant and that their extent is difficult to determine during surgical removal, makes them very dangerous. Since all of these tumors either produce calcified materials or replace bone, they can be detected in roentgenograms. Biopsy should be performed in the presence of any unexplained radiopacity or radiolucency in the bones.

Of the malignant tumors of the jaws, the following are important:

Osteosarcoma

Osteosarcoma is the commonest of the malignant tumors involving the jaws. It is seen chiefly in persons between 10 and 25 years of age and may be either periosteal or endosteal in origin. Clinically it presents as a rapidly growing hard swelling of the jaws. Osteosarcomas are often painful and, if they involve the inferior dental canal, they are associated with paresthesia. As the tumor grows, migration and loosening of teeth and resorption of roots are common. Roentgenologically, various grades of radiolucency and radiopacity are seen, depending on the type of the tumor. In the sclerosing form the predominant features are a dense area of radiopacity, destruction of the cortex, obliteration of normal architecture of the marrow, and formation of periosteal bone. Since the latter is formed in spicules which are at right angles to the cortex, it gives the so-called "sun ray" effect in the roentgenogram. The osteolytic forms of this tumor produce irregular radiolucency and destroy the cortex. Many tumors show osteolytic as well as osteosclerotic areas.

Chondrosarcoma

Chondrosarcoma usually occurs in persons between the ages of 25 and 50 years. These tumors involve the mandible more often than the maxilla and, in these bones, predominate in the ramus and the anterior portion, respectively. They are slow-growing and produce swellings of varying size. They may be associated with migration and loosening of teeth and root resorption. Roentgenologically, chondrosarcoma produces a mottled appearance.

Fibrosarcoma; Ewing's Sarcoma; Reticulum Cell Sarcoma

Fibrosarcoma, Ewing's sarcoma, and reticulum cell sarcoma are rare malignant tumors that sometimes affect the jaws. While the fibrosarcoma and reticulum cell sarcoma occur at any age, Ewing's sarcoma is seen chiefly between the ages of 10 and 25 years. The clinical

features of these tumors are not diagnostic. They produce pain, swelling and paresthesia. In roentgenograms they show irregular areas of radiolucency. Ewing's sarcoma is associated with fever and leukocytosis and therefore is very often mistaken for osteomyelitis.

In connection with these tumors, *myxoma* should also be mentioned. It does not metastastize, but is of an infiltrating and aggressive nature. It should be considered locally malignant, because it is very difficult to eradicate. It is characterized by a slow-growing, usually painless, radiolucent mass in one of the jaws.

Multiple Myeloma

Multiple myeloma is a malignant, generalized, usually fatal tumor of bone marrow. It occurs after the age of 50 years and usually involves the axial skeleton, the facial skeleton and the femur. In about 30 per cent of the cases the jaw bones are involved and in 8 or 10 per cent these bones are initially affected. In view of this, it is of utmost importance that the dentist be familiar with this disease. Of the facial bones the mandible is most often affected, with the posterior part of the mandibular body the commonest site. In the jaws the tumor expands to produce pain, destruction of the cortex, numbness, and loosening of the teeth. Roentgenologically the lesions appear as clearly punched out, strikingly radiolucent areas of various sizes. They do not have a peripheral "reaction" zone, in other words, the margins of the radiolucency are not radiopaque.

In the extrafacial skeleton the skull and vertebral column and pelvis are common sites. Pain and pathologic fractures occur in the bones involved. There are a number of tests which aid in a diagnosis of multiple myeloma, e.g., the presence of Bence-Jones protein in the urine, hypercalcemia, hyperproteinemia, hyperglobulinemia and an increase in gamma globulins. The histologic picture is diagnostic.

In addition to multiple myeloma, so-called *solitary myeloma* may be seen in the jaws. As the name indicates, this is a solitary lesion which histologically and roentgenologically is identical to the multiple variety. It is now generally believed that the solitary myeloma is merely an early stage of the multiple form. The solitary lesion is accompanied by hypergammaglobulinemia and the presence of myeloma cells in the marrow.

Finally, myeloma may take the form of so-called *extramedullary soft tissue plasmocytomas*. These soft tissue tumors occur in the oral and nasal cavities, oropharynx and nasopharynx. They are pedunculated or sessile and are composed exclusively of plasma cells. These lesions may, after many years, terminate in generalized myeloma.

LESIONS OF SALIVARY GLANDS

In addition to the three major salivary glands there are numerous minor glands which are distributed almost all over the oral cavity. Their location is given below.[2]

GLAND	TYPE OF SECRETORY CELL
Parotid	Serous
Submaxillary	Mainly serous with few mucous
Sublingual	Mainly mucous with few serous
Accessory sublingual glands	Mixed, mainly mucous
Glands of lip	Mixed, mainly mucous
Glands of cheek	Mixed, mainly mucous
Glossopalatine glands	Pure mucous
Anterior lingual glands on sides of median line under apex of tongue	Mixed
Glands of von Ebner (associated with circumvallate papillae)	Serous
Glands of root of tongue	Mucous
Glands of posterior half of hard palate (anterior half is free of glands)	Mucous
Glands of soft palate	Mucous

Any of these glands may be the site of malignant neoplasms. Of the various types of malignant salivary gland tumors, those most frequently seen are *adenocystic carcinoma, muco-epidermoid carcinoma* and *adenocarcinoma.* The details of these tumors are beyond the scope of the present discussion, but it is essential to remember that the commonest site of these tumors among the major glands is the parotid and intraorally they are most frequent in the palate.

Swellings in the parotid area which grow rapidly, are fixed to the tissues, do not fluctuate in size and are associated with some minor or major neurologic disturbance are most likely malignant salivary gland tumors. These clinical features are also applicable to the lesions of sublingual and submaxillary glands and the minor glands of the oral cavity. The palatal tumors usually are also characterized by destruction of bone and loosening of the regional teeth. Since all these tumors are malignant, metastasize and kill, they must be considered in a differential diagnosis of all swellings in and around the oral regions and of all radiolucencies of the maxilla.

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The Dental Patient with Heart Disease

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Close cooperation between the dentist and the family physician or internist is essential in the care of the dental-cardiac patient. To be emphasized are the prevention of subacute bacterial endocarditis, the evaluation of the cardiac-operative risk, and the principles of management before, during and after oral surgical procedures, especially when special drugs are being therapeutically administered for various cardiovascular disabilities. Few cardiac patients need be denied necessary dental therapy or oral surgery if proper liaison and management exist.

SUBACUTE BACTERIAL ENDOCARDITIS

This is a serious, even fatal, disease complication which is especially important in this discussion of the dental patient with heart disease because it frequently follows a dental procedure in persons with cardiac lesions and because it may be preventable today with appropriate penicillin prophylaxis.

Subacute bacterial endocarditis (S.B.E.) results from bacterial infection of the endocardial lining of the heart (valves) and is characterized by fever, heart murmur, bacteremia, anemia, splenomegaly, and embolic and local vascular phenomena. In the great majority of cases, the causative organism is the non-hemolytic *Streptococcus viridans* (alpha), a common inhabitant of the oral cavity and frequently found in periodontal disease and periapical abscesses. These bacteria from such a focus may gain entrance to the blood stream (bacteremia) and be carried to the heart to be implanted at endocardial sites previously damaged by disease, there to multiply into colonies, form vegetations, and produce erosions and ulcerations with their devastating sequelae.

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Pathogenesis

Underlying Heart Lesions. In the majority of patients, the bacterial implantation occurs on a valve which has been scarred by rheumatic fever. Interestingly enough, valves only slightly damaged (e.g., mild mitral insufficiency) appear to be more susceptible than those extensively scarred (e.g., severe mitral stenosis). Changes caused by congenital defects (e.g., ventricular septal defect, patent ductus arteriosus, coarctation of the aorta) and uncommonly by syphilis may provide the "soil" for the infection. In older patients, atheromatous changes in the aorta and aortic valve may be the site of the bacterial implantation, and it has been stated that "normal" valves may rarely be involved.

Bacteremia. The other important factor in the pathogenesis (and in the prevention) of subacute bacterial endocarditis is the bacteremia. Actually, intermittent or transient bacterial invasion of the circulation not uncommonly occurs in many of us! Normally, such showers of bacteria are innocuously cleared by the body's phagocytic defense mechanisms without serious mishap. However, bacteremia in patients with heart lesions may, as stated, lead to bacterial endocarditis.

Dental Extractions. That bacteremia can occur following dental extractions has been demonstrated by implanting the organism *Serratia marcescens* about the teeth and subsequent to tooth extraction, recovering this non-pathogen from the blood stream.[1] Furthermore, transient bacteremia has been reported within a few moments after extraction of teeth in 75 per cent of patients with oral sepsis and in 34 per cent of individuals without obvious oral infection.[10] In the majority of these cases, non-hemolytic streptococci of the viridans type (the predominate causative organism of subacute bacterial endocarditis) were recovered from the blood and these streptococci were culturally and serologically similar to strains derived from the mouth. It is not difficult to appreciate the repeated clinical observation that S.B.E. may occur in cardiac patients following dental extactions. Elliott[4] has also shown that the preliminary "rocking" of a tooth prior to extraction may initiate a bacteremia and that this bacterial invasion of the blood stream may be lessened or absent if tooth "rocking" manipulations are avoided. Burket and Burn[1] further emphasized in this regard the importance of improved sterilization of the gingival crevice prior to extraction.

Gum Manipulations. Other less traumatic dental procedures and manipulations which disturb the gums, such as brushing, scaling, or filling teeth, or, for that matter, merely the massaging and grinding with eating and chewing in patients with dental or gingival infection,

may produce transient bacteremia. In short, even without obvious surgical trauma, organisms may "leak" into the blood stream of persons with septic mouths. Of 110 persons with oral sepsis, 10.9 per cent were found to have (on a single examination of the blood) a streptococcal bacteremia *before* any surgical intervention.[10] Since slight gingival injury is sufficient, the presence of infection appears to be more important than the degree of trauma in the production of this type of bacteremia. Severe, chronic infection of the gingivae is the common culprit. Interestingly enough, acute apical infection is not as commonly associated, perhaps because this focus is more "walled off" by the inflammatory reaction.[4]

Foci of Infection

The important implications of oral infection in this cardiac complication are obvious, though forcefully brought forth in a recent paper[7] from England in which the dental status of 43 patients hospitalized with S.B.E. was compared to that of unselected controls. From the evidence, the teeth were incriminated as the chief source of infection. It was noted that S.B.E. due to *Streptococcus viridans* never occurred in their experience in a patient who was edentulous (full dentures and no visible teeth)! Furthermore, the major cause of relapse of the disease was considered to be failure to eliminate the primary dental focus. On their belief that teeth, "good" or "bad," present a preventable hazard to these patients, all teeth were removed in 7 patients who had at least one attack of S.B.E. Though admittedly a small number of patients, none so far had relapsed after 15 months to 7 years (the expected relapse rate is given as 1.4). They conclude that in all such patients "scrupulous, complete dental clearance" should be an essential part of the therapy.

Penicillin Prophylaxis

In patients with rheumatic or congenital heart disease (and perhaps even in elderly patients with calcareous aortic lesions) undergoing oral surgical procedures or dental and gingival manipulations, prophylactic antibiotic protection from the hazard of an incident bacteremia is advised. Penicillin is the usual drug of choice since most of the strains of *Streptococcus viridans* which cause S.B.E. are sensitive to this antibiotic. In addition, in appropriate (high) dosages, penicillin is not only bacteriostatic but bactericidal and is able thereby to eradicate the causative organisms. High blood levels of penicillin should be present at the actual time of the dental procedure and be maintained

for several days thereafter to combat adequately a transient bacteremia and thereby prevent endocardial implantation of organisms. The usual dosages effectively employed in long-term rheumatic fever prophylaxis are not adequate in this regard.

The currently recommended dosages and methods of prophylaxis against S.B.E. given by the American Heart Association are:[3]

First Choice—Intramuscular and Oral Penicillin Combined. For 2 days prior to surgery, 200,000 to 250,000 U. by mouth 4 times a day. On day of surgery, 200,000 to 250,000 U. by mouth 4 times a day *and* 600,000 U. aqueous penicillin (intramuscularly) with 600,000 U. procaine penicillin (intramuscularly) shortly before surgery. For 2 days after, 200,000 to 250,000 U. by mouth 4 times a day.

Second Choice—Oral Penicillin. 200,000 to 250,000 U. 4 times a day beginning 2 days prior to the surgical procedure and continued through the day of surgery or dental procedure and 2 days thereafter.

Conceivably, certain clinical problems might suggest more vigorously modified regimens. In very extensive oral surgical procedures, in the presence of severe oral sepsis, or in the patient who has had a previous attack of S.B.E., larger dosages of penicillin perhaps might rationally be desired. If practical, the parenteral route solely might be preferred with its advantages of better and insured absorption with higher blood levels, though certain oral preparations (penicillin V) are stated to give levels similar to parenterally administered penicillin. Perhaps the maintenance of prophylaxis for several more days postoperatively might be desired, or the oral penicillin (especially if daily return visits of out-patients are not practical) might be bolstered by injection of a long-acting (repository) preparation, such as Bicillin (benzathine penicillin G). In any event, modifications might rationally increase but should not decrease the current prophylactic measures, and the individual patient or situation should not force short-cuts or short-changing to jeopardize seriously good medical and dental practice.

Allergy to Penicillin. All patients must be specifically questioned about allergic reactions to penicillin, and if any history of such hypersensitivity is elicited, penicillin is contraindicated. In these patients, it is suggested[3] that erythromycin or the broad spectrum antibiotics (oxytetracycline or chlortetracycline) be employed in full dosage for some 5 days, beginning treatment 2 days prior to surgery. These drugs are not advised where penicillin is tolerated, the latter, for reasons stated, being the drug of choice.

Failure of Prophylaxis. Antibiotic "prophylaxis" does not guarantee that S.B.E. will not develop in individual situations. That S.B.E. is prevented by such "prophylaxis" in a statistically significant number

of patients has even been questioned.[5] Should a patient develop fever or other relevant signs and symptoms within a month following the oral surgical procedure, the diagnosis of S.B.E. must be considered and appropriate investigations performed. Obviously, further antibiotic therapy should not be initially instituted without a diagnosis. Hospitalization, laboratory assistance, and medical consultation are ideally necessary. Unless the clinical situation critically demands immediate treatment, it is preferred that the causative organism be isolated by blood culture and its sensitivity to the various antibiotics determined.

Surgery in Subacute Bacterial Endocarditis

In patients with known S.B.E. being treated effectively with established antibiotic dosages, the most rational and the optimal time for required dental surgical procedures to be performed is *while* the patient is still receiving such (or increased) antibiotic coverage, as soon as the fever and major clinical manifestations of the disease have subsided, and *not* after the treatment course is completed and the patient is convalescent. This important fact is often overlooked.

THE EFFECTS OF SPECIAL DRUGS (ANTICOAGULANTS AND ANTIHYPERTENSIVES)

Anticoagulants

In recent years ambulatory anticoagulant therapy has been used in certain patients with coronary artery disease, rheumatic heart disease with peripheral emboli and in some patients with other manifestations of peripheral and cerebral vascular disease. Such candidates must therefore be specifically questioned before any surgical or extensive dental procedure is undertaken. Consultation with the patient's physician in this regard is imperative in order to avoid any undue bleeding and, at the same time, any marked disruption of the anticoagulant program.

Heparin. Heparin sodium, given at least once daily by injection, is not too often used on an ambulatory basis. Its main action of prolonging the clotting time of blood is of relatively short duration. By simply omitting the drug on the day of surgery, any excessive bleeding should be prevented. If possible, however, the blood coagulation time should be determined before surgery is attempted.

The "long-acting" or repository forms of heparin are occasionally used for cardiac patients. Since their effect may last 24 hours or

longer, with considerable individual variation, it is imperative that they be discontinued for one or two days prior to any surgery. The blood coagulation time should be checked before surgical intervention in a patient who has recently received a "long-acting" heparin preparation.

Dicumarol and Related Drugs. The majority of patients receiving anticoagulant therapy, particularly as out-patients, usually are taking one of the prothrombin-depressing drugs such as Dicumarol, Tromexan, Sintrom, Hedulin, Coumadin, etc. Our aim in using these preparations is to keep the prothrombin time between 20 and 30 per cent. In hospitalized patients a prothrombin time of 15 to 20 per cent is often maintained. Most out-patients require 50 to 75 mg. of Dicumarol daily, and their prothrombin times are checked approximately every 7 to 10 days.

The prothrombin time should be allowed to rise to approximately 60 per cent before any type of surgery is done. It is preferable to accomplish this by omitting the drug for several days or by reducing the daily dose over several days until, after periodic prothrombin determinations, this level has been reached. Since anticoagulant therapy will be continued after the dental procedure, the prothrombin time should be maintained at approximately 60 per cent even if the necessary surgery extends over several days. This can be satisfactorily done by maintaining the patients on a lower than average daily amount of their prothrombin-lowering drug, but daily prothrombin times must be obtained during this period. After surgery, full anticoagulant therapy can be resumed.

Control of Hemorrhage. Since any dental procedure is rarely of an emergency nature, most patients on anticoagulant therapy can have their blood coagulation mechanism restored gradually toward normal as outlined above. This is particularly true of patients on heparin therapy, in whom the coagulation time will return to normal in 6 to 24 hours after an injection, depending on the type of heparin used. Protamine sulfate is the specific heparin antagonist. If needed to control any hemorrhage due to heparin, 50 to 100 mg. of protamine may be given intravenously. Blood transfusions may also be given if necessary.

Vitamin K_1 (Mephyton) is the drug of choice to be used to combat the hypoprothrombinemia induced by Dicumarol and related drugs. For minor bleeding at any time, or if for various reasons the prothrombin time may be considerably less than 60 per cent, Mephyton 2.5 to 10 mg. by mouth should restore the prothrombin time to safe levels promptly. If an emergency should require the restoration of the prothrombin time to normal, 25 to 50 mg. of Mephyton intravenously

will usually accomplish this in 8 to 14 hours. Blood transfusions may also be used in conjunction with Mephyton.

In the absence of bleeding, except when one would like to raise prophylactically a low prothrombin time (e.g., less than 10 per cent) to safer levels, it is preferable to allow the prothrombin time to return to more normal levels by omitting or reducing the dosage of the responsible drug rather than by the use of Vitamin K_1. This is desirable since it has been noted that following such therapy, the patient may become temporarily refractory to the reinstituted anticoagulants.

Antihypertensive Drugs

The many drugs recently introduced in the treatment of hypertension constitute another group of agents that have gained widespread use. These include the various Rauwolfia preparations, Apresoline and the more potent ganglionic (sympathetic and parasympathetic) blocking agents such as Inversine, Ecolid, Ansolysen and the hexamethonium compounds. For those patients taking the Rauwolfia preparations or Apresoline, no particular change in regimen is necessary during dental or surgical procedures other than stopping the drugs the day of surgery if general anesthesia is to be used. Patients whose hypertension is severe enough to require the use of the blocking agents should be hospitalized for any surgery requiring general anesthesia. Since the hypotensive effect of these drugs may be increased with such anesthesia, a gradual reduction in dosage over a period of several days, with omission of the drug on the day of surgery, is desirable. The blocking agents, however, should not be stopped abruptly.

If a hypotensive episode, characterized by dizziness, pallor, cold perspiration or actual syncope, should occur secondary to the blocking agents during any dental procedure, it is imperative to place the patient in the recumbent position immediately. This maneuver is usually all that is necessary to overcome the hypotension and its distressing symptoms, since the action of these drugs is exaggerated in the sitting or standing position. If the blood pressure does not promptly readjust, more vigorous measures including the use of vasopressor agents must be employed.

OPERATIVE RISK IN THE CARDIAC PATIENT

Operative procedures under general anesthesia involve a certain risk even in non-cardiac patients. In cardiac patients, these stresses may conceivably further burden a diseased heart, thereby adding to the usual risk of these procedures. A preoperative estimate of the risk

added by the heart disease to the risk of the surgical procedure itself is desired. However, the ability of the diseased heart to withstand a contemplated operation and the decision to operate in such patients is dependent upon many factors. In addition, each dental-cardiac patient presents an individual problem.

The Operation

In the majority of instances, the heart disease is not a contraindication to a *necessary* operation. The indication or necessity for the oral surgical procedure is usually the more important factor in deciding operability. The disability due to the oral surgical disease and the risk entailed if surgery is withheld must be first considered. Obviously, if a condition is present which would be rapidly fatal without surgical intervention, emergency operation should be performed regardless of the heart disease. On the other hand if the situation is not so critical and the operation is an elective procedure, than the risk of non-surgical management must be carefully balanced against the risk of the operation.

This operative risk will depend upon the many variables of the individual case at hand—the patient, the nature of the surgical lesion, the magnitude of the surgical procedure, the available facilities, the skills of the surgeon and the anesthetist, etc. In cardiac patients, small differences in these factors with their hazards may affect the surgical morbidity and mortality more strikingly than in non-cardiac patients, since the diseased circulation, maintaining adequacy perhaps through various compensatory mechanisms, may not as effectively adapt to fluctuations associated with stress and may thereby sustain greater and even irreversible consequences. For example, anesthesia difficulties or operative hemorrhage and shock with hypotension and hypoxia may not be so well tolerated by the diseased heart, often enlarged in compensation for its inadequacies and thereby even more dependent on increased supply of blood, oxygen and nutrients. Thromboembolism occurs more frequently in cardiac patients and with its further impairment of circulatory efficiency, may not be as well sustained. Likewise, infection, fever, and excessive intravenous infusions (especially sodium-containing fluids) are not as well tolerated and not infrequently may precipitate heart failure in these patients.

Generally speaking, if the oral operation is beneficial and necessary, it is not common today with good surgical, anesthetic, and medical management for a cardiac patient to have to be deprived of dental operative benefits because of the risk. But even though an operative risk may be acceptably small, still the surgical procedure is not war-

ranted if the prognosis of the heart disease itself offers so little survival time that the disability and longevity of the patient would not be influenced by the unoperated surgical condition (i.e., the patient is not expected medically to survive long enough to profit from contemplated surgery). In summary, the operation itself with the cogency of its surgical indication, variables and associated implications is often the important factor in deciding operability in the dental patient with heart disease.

Cardiac Status

In the preoperative estimate of the risk added by the heart disease to that of the operation itself, it is essential to differentiate between *decompensated* heart disease (i.e., with significant impairment of cardiac function) and *compensated* heart disease (i.e., without significant impairment of function). For practical purposes, if a diseased heart is capable of carrying out the ordinary demands of a reasonably normal life, then it can be generally assumed that this heart should be essentially as capable as a normal one of coping with a major operation under general anesthesia. The surgical mortality is not reported substantially higher in these patients.[2] In the absence of cardiac decompensation and cardiac accidents, the risk is generally stated to be virtually the same as in "normal" patients. Conversely, in the presence of moderate to severe heart failure, the operative mortality increases. As Marvin[9] so concisely stated in 1928, "a damaged heart, whatever its physical signs, is the equivalent of a normal one for anesthesia and operation if it is carrying on an adequate circulation under normal conditions of life, with the possible exception of the syphilitic heart."

Though there may be recognized exceptions to the above general statements, nevertheless, valuable and practical information is obtained regarding the cardiac-operative risk by an adequate history of the patient's exercise tolerance—whether unusual shortness of breath or anginal pain occurs on exertion and if so, how much exercise can be performed before these symptoms occur.[13] A detailed history of the cardiac disability or the knowledge of the ability of the patient's heart to respond to effort may be more important in this estimate of risk than the physical examination of the heart, and may even be more revealing than complex laboratory studies. Especially significant is the fact that special tests (notably the electrocardiogram) may be within normal limits in the presence of heart disease and even in heart failure! This by no means is to imply that auscultation and other methods of physical diagnosis, or the electrocardiogram, x-ray and laboratory

studies are not useful and are to be abandoned, but rather to emphasize the paramount importance and practicability of the detailed history and its foremost availability.

The symptoms of breathlessness, pain in the chest, swelling of the ankles, weakness and easy fatigability, cough and perhaps hemoptysis should suggest cardiac disability and should indicate closer scrutiny and further evaluation, consultation and possibly medical preparation before surgery is routinely undertaken. In short, the dentist in estimating the cardiac-operative risk can often evaluate the functional cardiac status simply by an adequate history, which, if suggestive of diminished cardiac reserve, should lead to further evaluation.

Type of Heart Disease

There are various cardiovascular complications—thromboembolism, myocardial infarction, subacute bacterial endocarditis, arrhythmias, cardiac standstill, etc.—which may often be responsible for the added risk to operation of patients with heart disease.[8] An estimate of the likelihood of their occurrence in a particular patient would be of assistance in the preoperative evaluation of risk. It is not possible, unfortunately, to predict specifically these "accidents" in individual cases. There are, however, some types of heart disease which may be more likely than others to develop certain complications.

The operative risk of patients with rheumatic heart disease generally rather closely follows their cardiac functional status or degree of cardiac compensation, but such correlation is not so clear-cut in patients with coronary (arteriosclerotic) heart disease, in whom the surgical risk is found to be generally somewhat higher. The incidence of coronary thrombosis and myocardial infarction is, of course, higher in this latter group. The operative hazard is even greater in the presence of an acute myocardial infarction, within three months of a recent infarction, and in the presence of an impending infarction, which clinically is often heralded by more frequent and more easily precipitated anginal attacks. On the other hand, the complication of subacute bacterial endocarditis appears more often in rheumatic heart disease patients. Moreover, patients with calcific aortic stenosis, even without known precipitating factors, are subject to sudden death, a hazard perhaps increased by general anesthesia and surgical operations. Furthermore, embolization from the heart occurs classically from thrombi in the dilated atria of patients with atrial fibrillation, rheumatic heart disease and mitral stenosis and from a ventricular mural thrombus overlying a myocardial infarction in coronary heart disease patients. The presence of these various conditions then predis-

poses to certain complications and these in turn may increase the surgical morbidity and mortality.

Complete atrioventricular block with Adams-Stokes syndrome usually enhances the risk of operation. However, patients with asymptomatic fixed heart block and bundle branch block usually tolerate operative procedures satisfactorily, the results being more primarily dependent on the underlying heart disease. Likewise, in atrial fibrillation and various arrhythmias, which may occur in "normal" hearts but more frequently in those with organic disease, the outcome is usually more related to the existent heart disease and the state of cardiac compensation. Patients with uncomplicated hypertension usually are considered to be "good risks," but in the presence of not infrequently associated coronary artery disease, cardiac insufficiency, or renal impairment the operative risk is seriously increased. Likewise, in syphilitic heart disease the presence of associated angina pectoris or heart failure enhances the risk.

In conclusion, despite the various hazards, it should be re-emphasized that most patients with heart disease today undergo operative procedures and general anesthesia amazingly well. Those persons with congestive heart failure, coronary heart disease (and symptomatic complete heart block) and associated renal disease may present a greater risk which must be justified by the surgical indication. Proper care and management before, during, and after operation can further diminish this cardiac-operative risk.

PRINCIPLES OF MANAGEMENT OF THE CARDIAC PATIENT

The fundamentals of good oral surgical and medical practice should, of course, be incorporated into the management of cardiac patients undergoing dental operative procedures. In addition, special care and precautions may be of vital importance with these patients, in whom, as discussed previously, small differences in certain variables may be dangerously exaggerated. Indeed, the surgical outcome may well be dependent on the extra care and attention a "poor risk" cardiac patient receives. A few salient principles of therapy especially applicable to this group of patients will be briefly considered.

Preoperative Management

If heart failure is present in a patient requiring operation, the surgical procedure (unless an extreme emergency) ideally should be deferred until cardiac compensation is well achieved. Therapeutic measures to accomplish this include the use of bed rest, digitalis prepara-

tions, sodium chloride restriction and mercurial or other diuretics. Cardiac compensation, when restored, should be maintained for at least a week or two prior to operation, depending on the surgical disease. The patient should be in the best possible state of cardiac compensation before surgical intervention, since the operative risk is seriously enhanced in the presence of cardiac failure.

In a compensated cardiac patient who requires maintenance digitalis for control, this drug should be continued to surgery and thereafter as long as the indication (and no contraindication) exists. Quinidine might be administered preoperatively in patients subject to ectopic tachycardias or to frequent premature contractions, though the latter often initiate undue concern and usually do not require specific therapy. In patients with angina pectoris, nitroglycerin tablets (0.3 mg.) sublingually may be employed for the relief or prevention of anginal attacks, though rapidly successive over-use may be hazardous if hypotension is induced.

Physical and mental rest with relief of pain, apprehension, anxiety and fear should be accomplished with kind reassurance, simple explanations, and judicious use of analgesic and sedative drugs as necessary. When local anesthesia is employed in an apprehensive patient, perhaps a barbiturate such as phenobarbital 60 to 100 mg. by mouth might be given an hour or so before. Large dosages of narcotics and barbiturates, with their depressant effects on blood pressure and respiration and incident dangers of hypotension and hypoxia, must be avoided, especially in the elderly (more susceptible) cardiac patient. For the "moderate risk" patient of average build undergoing major surgery under general anesthesia in the hospital, our anesthesiologist recommends[11] preoperatively a barbiturate such as pentobarbital 50 to 100 mg. by mouth an hour and a half before operation and Demerol 50 to 75 mg. hypodermically a half hour after the barbiturate, but in more seriously ill patients a smaller dose of pentobarbital and no Demerol are suggested. It is better to err initially on the side of too little, since supplemental increments can always be given later if necessary. Scopolamine or atropine 0.3 mg. hypodermically about an hour before general anesthesia is also recommended to prevent excessive salivation which might interfere with gaseous (anesthetic and oxygen) exchange in the lungs. Atropine as a parasympatholytic drug might in addition be desirable for such effect in diminishing dangerous vagal reflexes. Tachycardia can also be so induced by this vagolytic effect, but in the dosages of atropine used here it is not usually observed and should not be a practical contraindication to use of the drug.

Cardiac patients do not tolerate well large amounts of intravenous infusions, especially sodium-containing fluids, which may precipitate

heart failure in these susceptible individuals. Overloading of the circulatory system with saline, blood, plasma, etc. must be avoided. Preoperative replacement of intravenous fluids in dehydrated cardiac patients—for example, those who are unable to take fluids by mouth because of oral lesions—must be conservative, erring preferably on the side of slight under-replacement. Likewise, in anemic cardiac patients with their many hemodynamic alterations, blood transfusions if absolutely indicated preoperatively should be cautiously administered in small increments. Perhaps packed red blood cells rather than whole blood might be more safely employed. As an added precaution, it is suggested that the patient recipient be sitting up during the intravenous administration, or at least with head and shoulders elevated, and that frequent medical observation and examination be performed during the infusion to avoid or detect early any incident pulmonary edema or congestive failure. If the latter are suggested the intravenous infusion can be immediately discontinued.

Infection, which increases oxygen consumption and may also precipitate heart failure in cardiac patients, should be treated and controlled with appropriate antibiotics as necessary preoperatively. Ideally, the causative bacteria should be culturally identified, their sensitivity to the various antibiotics determined, and the most effective antibiotic rationally employed. In any event, as a protective measure previously discussed, antibiotic (penicillin) prophylaxis against subacute bacterial endocarditis is generally indicated in cardiac dental patients preoperatively, to be continued through the day of surgery and postoperatively in the dosages outlined.

Operative Management

The management of the cardiac patient with compensated heart disease during surgery is essentially no different from that of the non-cardiac patient. With good surgical technique and anesthetic management, little additional risk is involved. However, in those persons whose cardiac reserve is limited, the surgeon and anesthesiologist must be cognizant of this. It is in these patients that hypoxia and hypotension must be particularly avoided because of their known deleterious effects upon the diseased heart, possibly precipitating pulmonary edema, a myocardial infarction or a cardiac arrhythmia.

The choice of anesthesia should be left to the dental surgeon or anesthesiologist, since it is the proficiency of the anesthetist rather than the particular anesthetic agent used which is important for the cardiac as well as the non-cardiac patient during surgery. Troncelliti[11] has recently discussed this most important aspect of surgical management.

When local anesthesia is to be employed, epinephrine should not be used in cardiac patients, or, if necessary, only in a concentration of 1:100,000 or less and in a total quantity of not more than 4 cc. because of its excitatory effect on the heart and blood pressure.

The position of the cardiac patient during the surgical procedure is important. In the barely compensated individual who is more comfortable sleeping with head elevated and who is short of breath on mild exertion, the upright position is of benefit. Finally, it is to be emphasized, as in the pre- and postoperative care, that overzealous administration of intravenous fluids must be avoided during the operation.

Postoperative Management

With good preoperative and careful, uneventful operative management, the postoperative period of the dental-cardiac patient should not routinely present undue problems, though many of the general principles discussed above must be maintained. If digitalis had been required prior to operation, it should be continued thereafter, as should previously required cardiac measures such as salt restriction and diuretics, as long as the indication (and no contraindication) exists. Penicillin prophylaxis against S.B.E. should likewise be continued postoperatively as outlined.

The oral surgical patient may not be able to take fluids adequately by mouth postoperatively, and recourse to parenteral administration of required fluids and electrolytes may be necessary. Again, caution is stressed in the use of intravenous infusions, especially sodium-containing fluids. It is perhaps generally advisable to avoid saline in the immediate postoperative period, but with good indication demanding, sodium-containing fluids such as saline, blood plasma, etc. may have to be given. Then such administration should be soundly conservative and with the precautions described previously in the preoperative preparation of these patients.

Important postoperative complications include various cardiac arrhythmias (especially paroxysmal atrial tachycardia and atrial fibrillation); thromboembolism (coronary thrombosis, phlebothrombosis and pulmonary embolism and infarction); angina pectoris and acute pulmonary edema or other manifestations of heart failure. The serious cardiac arrhythmias following operation may require treatment with digitalis, quinidine, potassium salts or Pronestyl, etc., depending on the nature of the abnormal rhythm and the circumstances under which it developed. The complications of thromboembolism, which may be death-dealing, occur frequently in patients (not necessarily post-

operative) with heart disease, especially in the presence of circulatory stasis, inactivity, and congestive failure. In addition, pulmonary embolism may give rise to acute cor pulmonale and be confused with coronary thrombosis or acute pulmonary edema of cardiac origin. Thrombosis in the leg veins is the outstanding, basic source of pulmonary embolism, and therefore prevention of such phlebothrombosis by passive and active movement in bed and early ambulation is paramount. Treatment may require the use of anticoagulants and perhaps venous (bilateral superficial femoral) ligation.

With proper management, congestive failure in the postoperative period is generally not common, even in the presence of serious heart disease, as P. D. White[12] points out, probably because these patients are having a regimen of bed rest. When heart failure does develop in this period, the usually associated causes, barring cardiovascular "accidents," include excessive administration of fluids, infection, and excessive blood loss during operation. Should cardiac decompensation occur postoperatively, the same measures previously stated can be instituted. Infection, as always but especially in these patients, requires prompt treatment and control (with appropriate antibiotics as indicated).

SUMMARY

The care of the dental-cardiac patient includes prophylactic measures and management techniques which are in certain respects unique for these particular patients. The prophylactic measures include the very important problem of antibiotic administration for the prevention of S.B.E. and the care which must be exercised in treating those who are receiving special drugs, particularly the anticoagulants and the antihypertensive agents. The management of this group of patients involves preoperative evaluation of the cardiac-surgical risk; adequate preoperative preparation with digitalis and other drugs as indicated; and proper operative and postoperative care, avoiding hypoxia, hypotension and excessive administration of sodium-containing fluids. With such management, most cardiac patients can be generally considered satisfactory risks for necessary dental operative procedures.

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Transient Bacteremias Associated with Dental Operative Procedures and Their Prophylactic Treatment

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It has long been recognized that bacteria may enter the blood stream from the oral cavity. At one time entry was thought to be dependent upon disease being present in the teeth and gums. In more recent years it has been demonstrated that microorganisms will gain access to the systemic circulation under certain conditions even though there be no obvious disease present in the oral cavity. Of course, there must be a mechanism to assist in the propulsion of organisms into the vascular tree. Usually the mechanism is a traumatic one, frequently the extraction of one or more teeth. However, under certain conditions, the mere act of mastication may be sufficient to send a shower of organisms into the blood stream. These views, which were once considered radical, have now received widespread acceptance. It is taken for granted that bacteremia does occur after manipulation of the teeth and gums. In certain types of systemic illnesses it is mandatory that the operating dentist adequately protect the patient against the sequellae and attendant complications that follow dental operative procedures.

REVIEW OF LITERATURE

The medical literature has recognized for many years that subacute bacterial endocarditis—a frequently fatal infection of the heart valves—has in a great many instances followed extraction of teeth. In 1908, Lord Horder[6] of Great Britain specified the need of directing attention to oral sepsis in patients with valvular heart disease in order to prevent bacterial endocarditis (then known as "infective endocarditis"). Since that time a host of investigators have reiterated this warning of the invasion of the blood stream originating in the teeth and gums

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and leading to systemic infection or subacute bacterial endocarditis, especially in those patients with antecedent valvular involvement.

In addition, there are numerous cases of bacteremia and septicemia that have followed dental surgery, frequently involving pyogenic organisms. However, although these may give rise to chills and fever with subsequent abscess formation, since they are rarely of fatal issue little notice has been given them in the literature and it is difficult to find more than a few well documented cases or even case reports to illustrate this fairly common occurrence.

Bacteremias have long been known to follow almost all surgical procedures. Shottmuller in 1911 was one of the first to call attention to bacteremia occurring after curettage of the uterus. In 1925, Seifert made an exhaustive study of many types of operative procedures and indicated that bacteria found their way into the blood stream after a simple appendectomy. He also made the interesting observation that extensive trauma particularly predisposed to bacteremia and that it also occurred more frequently after operations on bony structures that were infected than after surgical procedures limited to the soft tissues.

In 1930, Barrington and Wright reported bacteremias occurring after operations on the urethra, as had Scott a year earlier. Southworth and Flake reported bacteremias occurring after tonsillectomy, but, concurring with the view prevalent at that time, were inclined to feel that the organisms recovered represented contaminants. However, in 1939 Elliott reported 38 per cent positive cultures after tonsillectomy.

In 1932, Richards studied a series of 377 patients and subjected them to massage of "foci of infection" in various parts of the body. These foci included joints, gingivae, prostate and "boils." Massage of "infected gums" produced positive cultures in 3 of 17 cases, but the highest percentage of positive cultures was obtained in cases of "infected prostate," 4 of 6 being positive.

In 1939, Elliott, by selecting patients and using a highly refined blood culture technique, was able to produce a bacteremia in 86 per cent of 21 patients merely by manipulating a single tooth in its socket and without actually extracting the tooth.

In 1941, Murray and Moosnick[8] obtained blood cultures in 55 per cent of 336 patients with varying degrees of dental caries by taking arterial blood cultures in patients who had chewed a 1 inch cube of paraffin for a half hour. This is the best illustration in the literature that the trauma of forceful chewing in patients with dental disease can result in bacteremia.

It remained for Okell and Elliott,[9] in 1935, to demonstrate in unequivocal terms the bacteremia that occurs following extraction of

teeth, and in addition, to reveal that soiling of the blood stream occurs far more often than had previously been realized. In blood cultures taken immediately following dental extractions in 138 cases, they found 84, or 60.9 per cent, positive. In those 40 cases in which there was "marked dental sepsis" they had an incidence of 30, or 75 per cent, positive cultures. One of the more unusual features in this work was the fact that of 110 cases of periodontal disease, 12, or 10.9 per cent, were found to have a bacteremia existing in the control cultures taken immediately prior to the extraction of teeth. We believe that the patient's clenching his teeth while being "stuck" for the blood culture is sufficient to send a shower of organisms into the blood stream in many instances.

A year later Fish and MacLean produced positive blood cultures in a small series of cases.

However, it was in 1937 that Burket and Burn[4] proved conclusively that the organisms in the gingival sulcus found their way into the systemic circulation. By "painting" cultures of *Serratia marcescens* (*B. prodigiosus*) in the gum margin prior to extraction, they were able to recover this organism on blood culture in 17 per cent of 204 cases. This indicated clearly that the origin of the bacteria found on blood cultures arose in the periodontal pocket, since this organism rarely invades humans and is generally considered both non-pathogenic and non-invasive.

In the same year Marseille reported 42 per cent positive cultures in 100 patients. He also noted that more than one organism was recovered in 8 per cent.

Palmer and Kempf were able to recover organisms in only 17 per cent of 82 patients in 1939. However, in many of their cases only one tooth was extracted, a factor that, as we shall demonstrate, tends to reduce the incidence of bacteremia.

In 1941, Paquin was not able to do any better, getting only 16.5 per cent positive cultures in 85 cases immediately following extraction.

In 1942, Faillo found a 40 per cent bacteremia in a series of 20 patients. On reculturing he was able to obtain positive cultures as late as six hours after extraction. This in itself is very unusual, since the normal clearing mechanisms of the body tend to remove bacteria in a short period of time. Bacteremia that persists this long (six hours) usually indicates a focus of infection that is either intermittently or constantly feeding organisms into the blood stream. Another finding of interest by this same author was his opinion that electric cautery about the gingival tissues of the teeth about to be extracted "was found to be of benefit." Unfortunately, experimental work by others on this same field has not borne out these contentions.

In 1943, Northrop and Crowley had 12.8 per cent positive cultures in 97 control cases. In addition, they found 11 per cent positive cultures in 73 patients receiving therapeutic doses of sulfathiazole.

In 1944, Pressman and Bender, by using a highly refined blood culture technique, were able to obtain 83.3 per cent positive cultures in 30 control cases immediately after extraction, and 33.3 per cent ten minutes after extraction.

In 1948, Glaser, Danker, Mathes and Harford found 62.5 per cent positive cultures in 66 cases in which only one tooth was extracted, while in 24 cases of multiple extractions, 70.8 per cent were positive.

In the same year, Hirsh, Vivino, Merril and Dowling had 33.8 per cent positive cultures in 65 cases consisting of one or more extractions.

Using the same type of material in a series reported the same year, Rhoade and Schram found 35.3 per cent positive cultures in 68 control cases.

In 1950, Robinson et al., in a massive study of 559 cases, were able to obtain positive cultures in only 21.1 per cent of their cases. By using a more refined technique and selecting their cases, they were able to elevate this to 39 per cent.

In 1950, Robinson et al. demonstrated a 78 per cent incidence of bacteremia in 25 blood cultures.

It becomes apparent that there is a wide variance in the incidence of bacteremia following dental surgery. The reasons for the differences in positive cultures obtained following extraction of teeth are manifold —no two investigators used the same techniques. Strictly speaking, it is almost impossible to compare their results. But by analyzing the various factors involved we can point out how it is possible to obtain a high incidence of positive cultures. Then, by avoiding the pitfalls demonstrated, we can better learn how to protect our patients.

FACTORS IN DENTAL BACTEREMIA

There are various factors which modify and influence the passage of organisms from the oral cavity into the blood stream. Some are local, both endogenous and exogenous; others are systemic and are mainly endogenous. We will attempt to show how each of these factors operates in the production of bacteremia.

Anesthesia

Burket and Burn[4] suggested that epinephrine, when introduced into peridental tissues together with a local anesthetic such as 2 per cent procaine, constricted the capillaries and prevented the ready access

of organisms into the blood stream. Feldman and Trace concurred with this view, as did a number of other investigators. Round, Kirkpatrick and Hails held the opposite view, believing that epinephrine, by increasing tissue tension, depresses the area of vitality and resistance and may allow a residual infection to be established. H. H. Brown believed that forcing fluid into tissues when under tension tended to force organisms into the lymphatics and into the blood stream. The investigators all felt that general anesthesia was preferable to local anesthesia as a means of preventing postextraction bacteremia. Not all of the investigators quoted in our survey indicated precisely the conditions under which the dental operative procedures were carried out, but even so, it is seen that those who used a local anesthetic plus epinephrine or some other vasoconstrictor had a lower percentage of postextraction bacteremias than did those workers who used either general anesthesia or conduction anesthesia. However, in an unpublished study comparing the same types of cases with and without epinephrine, we (Pressman and Bender) could demonstrate no statistical difference.

Another interesting reason for the use of procaine is the work of Villardo,[14] who demonstrated that procaine inoculated subcutaneously into rabbits increased the bactericidal and phagocytic power of the blood. In this manner it acted as both a local (in combination with epinephrine) and a systemic barrier to the entrance of organisms into the blood stream.

Culture Techniques

The problem of isolating organisms circulating in the blood stream is one of peculiar difficulty. Culture techniques must be of unusual sensitivity since it soon becomes apparent that the offending bacteria are, relatively speaking, few in number. We believe that the following factors are of importance in blood culturing:

Quantity of Blood Sample. The larger the sample, the greater the opportunity for a positive culture. Of course, there are limits, and we feel that a single sample of 16 to 24 cc. of blood is adequate and still gives the maximal chance of obtaining a positive culture.

Number of Aliquots. If the bacteremia is fairly heavy, the number of aliquots is not particularly significant. If the bacteremia is sparse, we have reason to believe that 4 cc. blood samples in four different culture flasks give slightly better results than 16 cc. of blood as one sample diluted in four times as much medium. Since we first called attention to our use of multiple aliquots,[1,11] to our best knowledge the only other investigators to favor this method and to strongly point out

its superiority as a method for increasing positive blood cultures are Robinson et al.[13]

Dilution Factor. This concerns the ratio of blood to medium. The standard ratio of 1 part of blood to 10 parts of medium appears to be adequate. We have varied the ratio to as little as 1 to 5 and as much as 1 to 20 without noting any apparent statistical difference. Robinson et al., in their studies, felt that they were able to detect a statistical difference indicating fewer positive cultures when using a 1 to 5 ratio (specifically, 20:100), and suggest that that ratio should not be used.

Type of Medium. Our experience has been such that we have found brain-heart infusion broth (Difco) best for the growth of *Streptococcus viridans.* This organism is the most frequent inhabitant of the oral cavity and is the causative agent in 85 to 90 per cent of all cases of subacute bacterial endocarditis. However, it seems that practically every worker in the field used a different type of medium. Tryptic digest broth enriched with dextrose, tryptose phosphate broth, and trypticase soy broth are only a few of those used. A number of investigators, in common with us, used thioglycollate broth for anaerobic growth.

Use of an Inhibitor in Culture Media. Blood possesses an inherent antibacterial action. Also, the polymorphonuclear leukocytes tend to remain active in culture media for up to 24 hours, engulfing bacteria still present in the blood. Therefore, it is necessary to add an inhibiting agent such as saponin or Liquoid (sodium polyanetholsulfonate) to lyse the white blood cells and inhibit the antibacterial action of the blood.

Inactivators for Antibiotics. This is another controversial factor. Some investigators claim that whatever antibiotic may be present in the blood is "diluted out" by the medium so that it no longer can maintain an inhibitory effect. We ran a special study on patients receiving penicillin to check on the necessity for the addition of an inactivator to blood cultures taken from these patients. We found it necessary to add an inactivator such as penicillinase, otherwise the percentage of positive cultures was sharply reduced. The dilution factor was not adequate to sufficiently remove the chemotherapeutic effect of the penicillin. Inactivators are not necessary for streptomycin in the presence of blood and medium, since blood and medium inactivate this antibiotic by the fourth day of culturing. There are no known inactivators for tetracycline (Achromycin, Tetracyn, etc.), chloramphenicol (Chloromycetin), chlortetracycline (Aureomycin) and oxytetracycline (Terramycin).* The significance of this is that

* Recently magnesium sulfate has been suggested as an inhibitor for the tetracyclines, but it is of "relatively little value" according to Finland.

when patients who have received doses of these drugs giving therapeutic blood levels are submitted to blood cultures, frequently nothing will grow out in vitro even though bacteria may be present, because of the continuing inhibition of the chemotherapeutic agent. These are then false negative results. This will be discussed in more detail later in this article.

Length of Time Blood Cultures Should Be Retained. In an attempt to prove a bacteremia, especially in cases of subacute bacterial endocarditis, there are some who advocate keeping blood cultures for up to 30 days. In our experience, streptococci, if they are going to grow out, usually do so within 48 hours. We have never seen a positive culture develop after 7 days, if it has not started to grow out in the first 2 days, although we have retained cultures up to 2 or 3 weeks on occasion. Unless some unusual or exotic organism is suspected, there is very little point in keeping cultures longer than 7 days.

Number of Teeth Extracted

It is generally agreed by practically all authorities that no more than one or two teeth should be removed at a sitting. Where it is desired to give the patient maximal protection, only one tooth should be removed. There is no way of assessing whether one tooth removed at a time on five different occasions is less likely to cause trouble than five teeth extracted at one time in any given patient. The weight of evidence favors the former on the basis of statistical evidence, despite the hazard of five separate anesthesias.

Trauma Produced at the Time of Extraction

The incidence of bacteremia is directly related to the degree of trauma. In an evaluation of some 94 control patients (Table 1), mild or grade I trauma was followed immediately by bacteremia in 68.7 per cent of the control patients. Severe trauma (grade II) was followed by bacteremia in 93.4 per cent of the control patients. Blood cultures of samples withdrawn 10 minutes later showed, as would be expected, fewer clear-cut differences: 34.3 per cent positive after mild trauma, 49.1 per cent after severe trauma.

We also analyzed our data according to the number of positive blood culture flasks, since in the above analysis, a positive is a positive whether only one flask shows a growth or whether growth occurs in all four flasks that were cultured for each patient.

The greater the degree of trauma, the greater is the number of organisms discharged into the blood stream and the greater the likeli-

TABLE 1. *Degree of Trauma versus Effectiveness of Antibiotics against Bacteremia (Evaluated by "Patient Analysis" and by "Flask Analysis")*

			IMMEDIATELY AFTER EXTRACTION							TEN MINUTES AFTER EXTRACTION					
			PATIENTS			FLASKS*				PATIENTS			FLASKS		
	TRAUMA	TOTAL CASES	NO. POS.	PER CENT POS.	P†	TOTAL NO.	NO. POS.	PER CENT POS.	P	NO. POS.	PER CENT POS.	P	TOTAL NO.	NO. POS.	PER CENT POS.	P
Control	I	32	22	68.7	—	115	57	49.5	—	11	34.3	—	114	21	18.4	—
	II	61	57	93.4	—	200	154	77.0	—	30	49.7	—	192	70	36.4	—

From Pressman and Bender, reference 10.
*Computed on aerobic flasks only.
†P = probability.

hood that organisms will get into each flask. Inspection of the table shows that the percentage of positive flasks was greater for patients with grade II, or severe trauma (77 per cent positive), as compared with grade I, or mild trauma (49.5 per cent positive). This corroborates the analysis by patient: severe trauma is followed by a greater shower of organisms into the blood stream.

Relationship of Periodontoclasia to the Incidence of Bacteremia

It would seem logical to assume that the degree of bacteremia should vary in direct proportion to the severity of the gum disease present. There is a difference of opinion, but the weight of evidence points to a lack of any relationship. Our own experience, that of Burket and Burn,[4] and that of Robinson et al.,[13] all point to no relationship between the degree of periodontoclasia and the incidence of bacteremia. One reason that may be advanced is that in the most severe grade of periodontoclasia the teeth to be removed were so loosely situated in their sockets because of the attendant disease that they could be extracted with very little effort and minimal trauma. Thus surgical trauma, the factor that mainly initiates the bacteremia, was not operative, and a lesser percentage of positive cultures was obtained.

Effect of Cauterization of the Gingival Sulcus on Dental Bacteremia

At one time it was felt that cauterization of the gingival sulcus by sealing the capillaries of the gingival tissues might prevent bacteremia. What were presumed to be ideal cases—isolated single-rooted teeth—still caused a bacteremia when the tooth was extracted, although the incidence was not as great as in the control cases. In cauterizing the sulci of posterior and multi-rooted teeth it is difficult to avoid injury to the adjacent periodontal tissues, and cauterization therefore would not be advisable. Thus, the use of cautery is limited under practical conditions. No complications such as infection, dry socket, or pain develop but a delay in healing is observed.

Mode of Entry of Organisms into the Blood Stream

As mentioned earlier, Burket and Burn[4] demonstrated that the organisms get into the blood stream from the gingival trough. Gunter and Appleton[5] have shown that the pulp tissue is sterile if cultured prior to extraction *in situ*, yet following extraction this same pulp tissue will yield organisms on culture. How do these organisms obtain entry?

Fish and MacLean ascribe it to the pumping action of the rigid

tooth in its rigid socket, forcing organisms through the blood and lymph channels of the periodontal membrane. Burket and Burn believe it to be due to the piston-like action of the tooth during extraction, while others assume that it is due to lowered "tissue resistance." However, none of these explanations account for Murray and Moosnick's demonstration[8] of bacteremia following vigorous chewing.

What seems to be generally overlooked is the fact that the veins operate under negative pressure. Thus the rupture of large veins during an extraction, or rupture of the smallest venules during forceful chewing, will permit saliva containing organisms to be aspirated into the venous system.

Method of Removal of Organisms from the Blood Stream

Considering the myriad organisms that inhabit the mouth and the ease with which they can enter the circulation, the surprising finding is that cultures are not uniformly positive after extraction. This may be attributed in part to the efficient clearing mechanism that exists within the body, also to the mechanical difficulties of culturing discussed earlier.

The speed of the clearing mechanism is shown in our control group in which immediately following extraction 79 of 93 cases (84.9 per cent) were positive but in 10 minutes had been reduced to 41 of 93 (44.1 per cent). We did not take cultures beyond 10 minutes. Investigations by Reichel[12] have shown that in the experimental animal, despite the injection of tremendous numbers of live bacteria into the blood stream, complete removal was effected in 20 to 30 minutes.

Petersen, Miller and Borhan injected intravenously a suspension of five million to ten million live *B. coli* per cubic centimeter into dogs for varying periods of time and found that the bacteria were removed by the reticulo-endothelial cells, principally in the liver. Despite the overwhelming concentration of organisms, they found the dogs able to resist up to 12 hours before the reticulo-endothelial system seemed to be critically injured. Reichel indicated that the clearance capacity is seemingly independent of the powers of resistance of the host, i.e., chronically ill animals remove organisms just as rapidly as normal animals.

Yet despite the seemingly inexhaustible power of the reticulo-endothelial system to remove bacteria from the circulation in short periods of time, there is sufficient evidence to indicate either that the methods of removal are far from perfect or that there are so many modes of entry or "leaks" into the circulation that the body clearing mechanism is hard pressed to maintain the vascular tree free of organisms. There

have been repeated studies done in which blood cultures taken at random under the strictest aseptic precautions have demonstrated a bacteremia. The inescapable conclusion is that soiling of the blood stream frequently occurs, but that the clearing mechanisms of the body almost always remove these offenders before any damage can be done.

Action of Antibiotics in Suppression of Bacteremia

Antibiotics are either bacteriostatic or bactericidal. The bacteriostatic group, which acts by inhibiting growth and reproduction, consists of the broad spectrum antibiotics—the tetracyclines (Aureomycin, Terramycin, Achromycin) plus chloramphenicol (Chloromycetin) and erythromycin. The bactericidal group, which actually kills organisms, consists of penicillin, streptomycin, bacitracin, polymyxin and neomycin.

The mechanism by which organisms are either suppressed or destroyed is essentially one of interference with the enzyme systems that control the metabolism of the bacteria. It varies with each individual antibiotic.

It becomes apparent, then, that there are several factors to be considered when one exhibits an antibiotic prior to a contemplated oral surgical procedure.

State of Organism. Since all metabolism is at its highest during the stage of growth and reproduction, antibiotics are most effective against a bacterial population that is actually growing. Since organisms are continually being washed out of the mouth, we are rarely dealing with a static population.

Number of Available Organisms. The more organisms present, the better is the chance that one will survive to resist and even destroy the antibiotic. However, there is a corollary to this, that if an antibiotic such as penicillin is exhibited prematurely, the penicillin-sensitive organisms are knocked out only to be rapidly replaced (within 2 to 3 hours) by penicillin-resistant organisms. For this reason, we feel, and can prove, that a parenteral antibiotic given no more than 1 hour prior to dental surgery gives not only maximal blood levels but also maximal suppression of the salivary population count.

Chemical and Physical Nature of Environment. One must take into account the physical attributes of the mouth that are conducive to growth of organisms—the ability of organisms to secrete themselves in the gingival sulcus where they defy eradication.

Concentration of the Antibiotic. In the environment of the organism, any antibiotic given parenterally must be elaborated in the saliva

to be effective in the mouth. Penicillin, an outstanding example, is not excreted into the saliva in effective amounts. Although it may give some measure of protection in the blood stream, it has little or no protective power in the saliva. If it is felt desirable to kill the organisms at the source—e.g., in the mouth—it is necessary to prescribe a troche containing an antibiotic or combinations of antibiotics to be administered just prior to surgery.

Types of Bacteria Incident to Bacteremia, and Their Significance; Comparison with Population Counts of the Saliva

The streptococcus group is found most frequently and in the largest numbers in both blood and saliva. If a combination of organisms (such as diphtheroids and streptococci) have a high population count in the saliva, the same combination is frequently found in the corresponding blood samples. An organism is rarely recovered in the blood which had not been found in the saliva. There is one discrepancy: *Streptococcus anhemolyticus,* which is frequently the most populous inhabitant of the saliva, is not recovered nearly as frequently on blood culture as is *Str. viridans.*

It is *Str. viridans* that is the greatest potential source of trouble, since this is the organism that is responsible for approximately 85 to 90 per cent of the cases of subacute bacterial endocarditis, as previously noted.

The third member of the streptococcus group, *Str. hemolyticus,* is not found nearly as frequently as the first two. It is of concern because it can cause a flare-up of quiescent rheumatic fever.

The pneumococcus group is frequently found and occasionally can give rise to an acute ulcerative endocarditis.

The staphylococcus group is found with a fair degree of frequency and constitutes a growing problem for two reasons. Frequently the organism is resistant to nearly all antibiotics, and recently this same resistant organism is causing more and more cases of subacute bacterial endocarditis.

Diphtheroid bacilli, *Micrococcus tetragenes,* and the Neisseria group are frequently found but rarely are pathogenic.

THE USE OF THE VARIOUS ANTIBIOTICS IN CONTROLLING BACTEREMIA IN DENTAL OPERATIVE PROCEDURES

In determining the antibiotic requirements preparatory and incident to dental operative procedures, there are three chief considerations that merit our attention:

1. The dental surgeon is working in an unclean field. Only when the dentist limits himself to a single tooth and excludes the gingiva entirely is it possible to get an aseptic field. It is also true that by means of flaps, a base of a tooth may be exposed and by means of sterile pads kept relatively sterile, but true sterility as practiced by the general surgeon is virtually unknown to the operating dentist.

2. In the extraction of teeth some degree of bacteremia is inevitable if true asepsis is impossible. This is usually ignored by the dental surgeon and given little or no consideration by the average physician when approached concerning his patient with rheumatic heart disease.

3. Therefore, if bacteremia originates in the mouth it behooves us to give our patient double protection. The first half is topical or local antibiotic protection by means of troches, and the second part is systemic or general protection by parenteral antibiotics.

Topical Antibiotic Protection

What type of antibiotic do we require? Ideally, we could use a *truly broad spectrum* antibiotic that is bactericidal against all organisms that inhabit the mouth. Unfortunately such an antibiotic does not exist as yet, there being no chemotherapeutic agent that will obliterate both gram-negative and gram-positive organisms and give us the unobtainable—a sterile mouth.

In view of this we have no recourse but to resort to polypharmacy in order to try to suppress the organisms in the mouth. By using various combinations of antibiotics in the form of troches it is possible to obtain marked reduction of the population count. Unfortunately, even with combinations these organisms cannot be obliterated.

In our experience, the most effective combination of antibiotics made up into a troche consists of 20,000 units of penicillin, 50 units of bacitracin and 0.130 gram of sulfadiazine. It is marketed under the name of Sul-pondet.

Normally, it is necessary to use only one troche, one-half hour prior to dental surgery so that the problem of a patient becoming sensitive does not enter into the picture.

When a patient is known to be sensitive to penicillin or the sulfa drugs, a different troche consisting of 5 mg. neomycin, 200 units of bacitracin and 2,000 units of polymyxin may be used. This troche is sold under the name of Wybiotic.

Systemic Antibiotic Protection

Consideration will now be given to the various chemotherapeutic agents that are available for systemic use (by oral ingestion or paren-

terally—usually intramuscularly but occasionally intravenously). Attempts to review the literature are meaningless, as no two investigators have even used the same technique and it becomes nearly impossible to compare results. Even when the same antibiotic has been used, variations in dosage again preclude any meaningful comparison. Hence, the following analysis of the various chemotherapeutic agents is based on the author's seventeen years' experience in this field.

Sulfonamides. It is generally conceded that for systemic protection, the sulfonamide give "too little too late" so that they are rarely, if ever, used. Where they are used, one of the "triple sulfa" combinations is preferred (to protect against formation of kidney stones) in a dose of 1.0 gram every four hours from 24 to 48 hours prior to extraction.

Broad Spectrum Antibiotics. This group is a second choice, principally because, as previously mentioned, they are bacteriostatic—they inhibit but do not kill. Moreover, although they are excreted into the saliva, the levels are frequently one-tenth of the blood levels so that the salivary concentration cannot be considered to reach therapeutic levels. The following dosage levels are generally used:

Chloromycetin (chloramphenicol) can be given orally in 250 mg. capsules. The therapeutic dose is 500 to 1000 mg. every 6 hours for 48 hours preceding surgery. It may also be given intramuscularly 1000 mg. one hour prior to surgery. It can be given intravenously when diluted with 250 to 500 cc. of diluent, 500 mg. in a single dose.

Aureomycin (chlortetracycline) is given orally in 250 mg. capsules. The therapeutic dose is 250 to 500 mg. every 6 hours. It is also given intramuscularly 100 mg. at a time or 1000 mg. intravenously one hour prior to surgery; this regimen appears to give adequate blood levels.

Terramycin (oxytetracycline) is given orally in 250 mg. capsules. The therapeutic dose is the same as for Aureomycin, 250 mg. every 6 hours. It can be given in 100 gm. doses intramuscularly, or in 500 to 1000 mg. doses intravenously. The latter must be diluted with 250 to 500 cc. of diluent. All should be given one hour prior to surgery, but the intravenous preparations can start several hours prior to surgery and continue up to the time of surgery. This is applicable to all intravenous antibiotics.

Achromycin, Tetracyn (tetracycline) is administered in the same dosages as Terramycin, but the phosphate complex form given by mouth gives higher blood levels. All of these agents, when given orally, are given two days prior to surgery, the day of surgery, and two days afterwards.

Erythromycin. Erythromycin is given orally in doses of 250 to 500 mg. four times a day (every 6 hours); it can also be given intramuscu-

larly or intravenously in 1000 mg. doses as erythromycin lactobionate.

Penicillin. Penicillin is considered to be the drug of choice. First, it is a bactericidal. Secondly, it is uniformly effective against *Str. viridans* (as mentioned before, the etiologic agent in subacute bacterial endocarditis and, of course, one of the principal inhabitants of the mouth).

Penicillin is given parenterally as either the aqueous crystalline salt or as procaine penicillin. The two are frequently combined, either in equal parts or as one part of crystalline to three parts of procaine penicillin. The minimum dosage advocated is 400,000 units and the maximum recommended is 1,200,000 units—all intramuscular. It can be given intravenously but is not generally used for this purpose.

Orally, penicillin is given in doses of 200,000 units four times a day for 2 days prior to surgery, the day of surgery and for 2 days afterward, as *phenoxymethyl penicillin* (penicillin V).

Streptomycin. Streptomycin is never given alone, but when combined with penicillin it exerts a synergistic effect. It is given usually in 1.0 gram doses and may be mixed in with the penicillin. We have advocated a mixture of 300,000 units procaine penicillin, 100,000 units aqueous crystalline penicillin and 1.0 gram of streptomycin. The dose of penicillin can be doubled, but it is usually considered that a 1.0 gram dose of streptomycin is sufficient.

DISEASES REQUIRING PROPHYLAXIS

1. *The Rheumatic Diathesis.* Prior to dental surgery all patients with a history of a "murmur" known to be organic, rheumatic fever, scarlet fever, pains in the joints, "growing pains," frequent "sore throats" or chorea should be warned of the possible complications that may develop. If necessary, consultation with a physician should be sought to establish diagnosis. In patients with known rheumatic heart disease, it is mandatory that the patient receive prophylaxis.

2. *Congenital Heart Disease.* All patients known to have this disease, or to have been a "blue baby" or to have had a murmur since birth, must be adequately protected.

3. *Arteriosclerotic Heart Disease.* In recent years, subacute bacterial endocarditis has occasionally been seen engrafted on an arteriosclerotic heart valve. When maximal protection is desired, prophylaxis is indicated.

4. *Hypertensive Heart Disease.* Simple hypertension is not an indication for prophylaxis, but the author feels that in any disease such as this where there is organic disease of the heart, the valves must receive protection.

5. *Syphilitic Heart Disease.* Patients with this disease definitely should receive prophylaxis prior to oral surgery.

6. *Diabetes Mellitus.* This disease is no longer a contraindication to any kind of surgery. Basically, these patients are treated as any others but it should be borne in mind that they are easy prey to infection and should receive antibiotic protection. Moreover, therapeutic doses of appropriate antibiotics should be maintained until healing is well established.

7. *Generalized Systemic Disease.* By this is meant any disseminated disease, such as collagen diseases, in which there may be cardiac involvement. Also, any disease in which there is debilitation presents a patient who is ready prey to the complications of oral surgery and deserves protection.

8. *The Geriatric Patient.* Any patient who presents the diseases of senility may be presumed to have latent arteriosclerotic disease and probably deserves prophylaxis.

RECOMMENDATIONS FOR THE PREVENTION OF DENTAL BACTEREMIA

The Council on Rheumatic Fever and Congenital Heart Disease of the American Heart Association appointed a committee on prevention of rheumatic fever and bacterial endocarditis. Also the Council on Dental Therapeutics makes certain recommendations in the December 1957 issue of the Journal of the American Dental Association. Both Councils make certain recommendations which are at variance with our own (Pressman and Bender[10]). However, we will present their recommendations and then point out the discrepancies that we feel exist in their regimens. The recommendations of the American Heart Association are presented in full.

Recommended Prophylactic Methods (American Heart Association)

"Penicillin is the drug of choice for administration to patients with rheumatic or congenital heart disease undergoing dental manipulations or surgical procedures in the oral cavity.

"Although the exact dosage and duration of therapy are somewhat empirical, there is some evidence that for effective prophylaxis reasonably high concentrations of penicillin must be present at the time of the dental procedure. The dosage regimens employed for long term prophylaxis of rheumatic fever are inadequate for this purpose. High levels of penicillin in the blood over a period of several days are recommended to prevent organisms from lodging in the heart valves during the period of bacteremia.

"Not only should penicillin prophylaxis be designed to afford maxi-

mum protection, but the method must also be practical. In general, the combined oral and parenteral route of administration is preferred. All patients should be instructed to report to their physician or clinic should they develop a fever within a month following operation.

"*First Choice—Intramuscular and Oral Penicillin Combined.* For two days prior to surgery—200,000–250,000 units by mouth four times a day. On day of surgery—200,000–250,000 units by mouth four times a day *and* 600,000 units aqueous penicillin intramuscularly with 600,000 units procaine penicillin intramuscularly shortly before surgery. For two days after—200,000–250,000 units by mouth four times a day.

"*Second Choice* (if injection is not feasible)—*Oral penicillin,* 200,000–250,000 units four times a day beginning two days prior to the surgical procedure and continued through the day of surgery or dental procedure and two days thereafter. Contraindications—a history of sensitivity to penicillin.

"*Other Antibiotics*—Erythromycin or the broad spectrum antibiotics should be employed as prophylaxis in patients who are sensitive to penicillin. In those who are undergoing surgery of the genito-urinary or lower gastro-intestinal tract, oxytetracycline or chlortetracycline should be administered in full dosage for five days, beginning treatment two days prior to the surgical procedure."

Penicillin and Postextraction Bacteremia (Council on Dental Therapeutics)

An informative report by the Council on Dental Therapeutics is quoted here in part, from the Journal of the American Dental Association, volume 55, p. 887, December 1957:

"In the light of current information, the Council has recognized the prophylactic usefulness of penicillin V when administered in adequate oral doses as an alternative to the parenteral injection of penicillin G for the prevention of postoperative bacteremias.

"The Council suggests certain considerations as minimum precautionary measures against the hazards of subacute bacterial endocarditis.

"Before penicillin therapy is started, the patient should be questioned to ascertain whether there may be a predisposition toward penicillin sensitivity. If there is a history of hay fever, allergy, asthma or previous reaction to penicillin, erythromycin or a broad-spectrum antibiotic should be employed instead. The actions, uses and doses of these drugs are discussed in *Accepted Dental Remedies.* The following dosage schedules are suggested:

"*Treatment of Choice.* About one-half hour before operation, the patient should receive intramuscularly 200,000 to 300,000 units of crystalline penicillin G with 600,000 units of procaine penicillin G. Postoperatively, the patient should receive an additional injection of 600,000 units of procaine penicillin intramuscularly 18 to 24 hours later. If this is not feasible, the patient should receive at least 200,000 units of an oral form of penicillin every 4 to 6 hours during the ensuing 48 hour period. Buffered penicillin G, benzathine penicillin G or a penicillin V preparation may be employed for this purpose.

"*Alternative Treatment.* At least 24 hours before operation, the patient should begin receiving 200,000 to 300,000 units of penicillin V orally every 4 to 6 hours. A 200,000 unit dose should be administered one hour before the operation, and postoperatively 200,000 to 300,000 units should be given four times a day for the ensuing 48 hours."

* * * * *

We feel that there are certain objections to these recommendations: (1) No effort is made to use topical application of a troche to suppress the organisms at the source. (2) Giving oral penicillin for two days prior to oral surgery allows the bacterial population of the mouth to become acclimated to penicillin and to develop penicillin-resistant strains. It does not give any higher blood levels, nor does it appear to serve any other useful purpose that cannot be obtained within an hour by the administration of the parenteral penicillin. (3) Parenteral penicillin should not be given "shortly" before surgery—one-half hour before surgery—but exactly one hour prior to surgery in order to achieve the maximal blood concentration at the time of the operative procedure.

Principles for Prevention of Bacteremia Following Dental Operative Procedures (Pressman and Bender)

1. Manipulation of the gums or teeth should be avoided whenever possible in patients known to have congenital malformations of the heart or to have suffered from any disease liable to damage the heart valves. Root canal therapy, if at all feasible, is preferable to tooth extraction because it produces less trauma.

2. Prior to oral surgery all such patients should be closely questioned. In the presence of such diseases, the patient should be warned of possible complications and should be seen by a physician in consultation with a dentist before oral surgery is begun.

3. Local anesthesia of the procaine type plus a vasoconstrictor should be used in preference to general anesthesia. It is our observa-

tion that extractions are performed with less trauma under local anesthesia.

4. Only one tooth should be removed at a time; multiple extractions are contraindicated in these patients. The extraction should be done with a minimum of "rocking" or trauma.

5. Antibiotics should be administered as follows:

a. One hour prior to extraction, 400,000 to 1,200,000 units of fortified penicillin (mixture of crystalline and procaine penicillin), 1.0 gram of streptomycin, intramuscular route.

b. One-half hour prior to extraction, one Sul-pondet or one Wybiotic troche to be slowly dissolved in the mouth.

c. Twelve to 48 hours after the extraction, 400,000 to 1,200,000 units of fortified penicillin, 1.0 gram of streptomycin, intramuscular route. To be given every 12 hours when added protection is deemed necessary. Penicillin V 250,000 units every 6 hours may be given for as long as necessary.

d. Penicillin-sensitive patients may be treated by intramuscular tetracycline 100 mg., Chloromycetin 1.0 gram or erythromycin 1.0 gram one hour prior to surgery as a substitute for the penicillin and streptomycin. Less desirable is to give tetracycline phosphate complex (Achromycin V, Tetracyn √) 250 to 500 mg. every 6 hours for 24 hours prior to oral surgery.

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Cutaneous Diseases of Interest to the Dentist

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The purpose of this article is to review for the dental practitioner some of the commoner disturbances of the skin and mucous membranes of the oral cavity. Some of these are induced by external and locally acting factors, while others represent oral manifestations of systemic processes.

In order to simplify the discussion, the lesions will be grouped according to certain clinical characteristics and in descending order of frequency, as follows:

Disturbances Characterized by the Appearance of Multiple Small Ulcerations of Lip, Tongue and Cheek Surfaces
- Aphthous stomatitis
- Erythema multiforme
- Herpetic stomatitis
- Early syphilis (secondary syphilis)
- Pemphigus

Disturbances Characterized Predominantly by Whitish Patches Sparsely or Widely Scattered on the Oral Mucosa
- Lichen planus
- Leukoplakia
- Moniliasis
- Lupus erythematosus

Single Lesions of Lips or Tongue
- Erosive and inflammatory lesions
  - Herpes simplex
  - Syphilitic chancre
  - Pyogenic granuloma

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Granulomatous lesions
Carcinoma
Syphilitic gumma
Tuberculosis
Warty lesions
Common wart
Miscellaneous Disturbances
Contact dermatitis
Benign migratory glossitis
Fordyce disease

DISTURBANCES CHARACTERIZED BY MULTIPLE ULCERATIONS

Aphthous stomatitis is particularly common in children and is characterized by small, round, discrete, painful ulcers which are usually covered by a yellowish gray membrane, and surrounded by a reddish margin (Fig. 1). They occur on the lips, edges and base of the tongue, and gingival gutters. This disease, which is of unknown origin, tends to recurrence, bouts usually lasting 1 to 2 weeks. The not infrequent association with labial herpes (fever blisters) has led to the assumption of a viral cause for this disorder, but this has not been verified by cultural proof.

Erythema multiforme is a recurrent acute symptom complex which involves the mucous membranes of lips, tongue and cheeks only in the form termed "bullous" or "Stevens-Johnson syndrome." There is usually a fairly severe systemic reaction of malaise and temperature elevation. The lesions may be widespread, involving the hands, dorsa and palms, and the lower legs in a symmetrical fashion. The genitalia are often involved. On the skin, surface lesions may be composed of concentric circles, giving rise to an "iris" type of eruption. This reaction pattern is occasionally observed as a form of "drug sensitivity," especially following the administration of sulfonamides, phenolphthalein, barbiturates, antipyrene, salicylates, butazolidin, mercury or arsenicals. A herpetic infection may at times precede it (Fig. 2). The course tends to spontaneous remission in 2 to 3 weeks, but severe forms usually necessitate treatment with ACTH or corticosteroids.

Herpetic stomatitis is most commonly seen in young children as a result of herpes virus infection. The oral lesions resemble those of aphthous stomatitis, but are more numerous and extensive and are accompanied by a much more severe systemic reaction and marked cervical lymphadenitis. Similar oral lesions are also found in adults in viral infections of the Coxsackie type.

Fig. 1. Fig. 2.

Fig. 3.

Fig. 1. Aphthous stomatitis—shallow ulcers along lip margins.
Fig. 2. Erythema multiforme following herpes simplex; involvement of tongue, lips, buccal mucosa, skin of face and hands.
Fig. 3. Early (secondary) syphilis. Tongue shows "bald" patches, enlargement of lymphoid tissue at base, "split papule" left labial commissure.

Syphilis. Oral lesions found in the first 3 or 4 months of an acquired syphilitic infection are rarely seen today, but they are important because of their infectiousness. Those which appear as ulcerative forms usually show a superficial gray erosion of the lips (mucous patches) or tongue, or involve the labial commissures ("split papule") (Fig. 3).

Pemphigus, an uncommon but serious and frequently fatal disease

TABLE 1. *Diseases Characterized by Multiple Ulcers and Erosions*

DISEASE	APPEARANCE OF INDIVIDUAL LESION	PRINCIPAL LOCATION	OTHER SITES INVOLVED	ASSOCIATED FINDINGS
Aphthous stomatitis	Painful small ulcers with inflamed base, may coalesce	Sides and base of tongue, inside lips	Slight to moderate lymphadenopathy	Few
Erythema multiforme (stomatitis medicamentosa)	Sharply circumscribed erosions, yellowish membrane or bloody crusting, intervening mucosa inflamed	Lips, tongue, cheeks, palate	Face, palms, flexors of wrists, genitalia	Lesions painful; fever, malaise; sore throat
Syphilis (early)	Few, small, gray-white on raised base	Oral commissures, lips, tongue, buccal mucosa	Lymphadenopathy, non-tender. Skin lesions not constant	Few or none. Sore throat at times, highly infectious
Pemphigus	Small to large superficial erosions, and ulcers with ragged edges, bleeding from lesions	Lips, tongue, cheeks, gingiva, pharynx	Skin lesions absent, few or generalized; genitalia and conjunctiva bullae and erosions	Weight loss, cachexia, fetor oris

of adult life, may involve the mouth long prior to the appearance of lesions on other parts of the body, and in such cases toothache is a frequent first complaint. Multiple, rarely single, irregular ulcerations develop which are painful and bleed readily. A characteristic fetid breath is present. The borders and inferior aspects of the tongue, the lips, gingivae, cheeks and pharynx may become involved. The lesions rapidly progress, show little tendency to heal and seriously interfere with the intake of food. The skin and mucous membranes of the patient with pemphigus share the property of loose adherence of epidermis and dermis so that ulcers occur on slight trauma or pressure (Nikolsky sign). When extensive involvement of the mouth is present the prognosis is poor, although prompt and adequate treatment with corticosteroids will usually result in a remission. At times a biopsy must be resorted to for exact diagnosis. The histologic features of pemphigus are quite characteristic, and these changes can be demonstrated in tissue as well as in scrapings taken from the base of the early pemphigus lesion.

DISTURBANCES CHARACTERIZED BY WHITE PATCHES ON ORAL MUCOSA

Lichen planus involves the buccal mucosa frequently and usually appears in the form of a lacelike bluish white pattern with intervening patches of normal mucosa (Fig. 4). The individual types range from pinhead-sized papules to annular and rarely erosive patches. The oral lesions are found frequently on the lateral cheek surfaces, dorsum and sides of tongue, lips and gums. They rarely produce symptoms. Skin lesions may be absent. When present they are characteristically found as angular papules on the wrist flexors, the lower legs and the genital mucosae. Considerable itching is usually complained of. Confusion of the oral lesions with leukoplakia is not unusual. The correct clinical diagnosis can usually be made on clinical grounds, but occasionally a biopsy may have to decide the issue.

Moniliasis of the oral membranes (thrush) appears with increasing frequency in the infant offspring of mothers with vaginal moniliasis and in patients on local or systemic broad spectrum antibiotics. Involvement of the mouth may be found on any portion of the mucous membrane. The usual appearance is that of curdled milk-like deposits which scrape off with difficulty, leaving a raw red surface (Fig. 6). A fissuring of the mouth angles (perlèche) may coexist. Effective treatment can now be prescribed in the form of a recently developed antibiotic, nystatin (Mycostatin). Underlying systemic factors include malnutrition and uncontrolled diabetes.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 4. Lichen planus of buccal mucosa near left commissure.
Fig. 5. Leukoplakia of right buccal mucosa. Early lesion of three months' duration.
Fig. 6. Moniliasis of tongue, buccal mucosa, and palate.
Fig. 7. Lupus erythematosus, lesions of right buccal mucosa and of lower lip.

Lupus erythematosus in both its chronic discoid and acute forms may show mucosal lesions resembling those of lichen planus. When present they usually are of serious prognostic import. They are found especially on the lips, palate and buccal surfaces (Fig. 7), presenting more or less well defined reddish patches with an eroded surface flecked with white.

TABLE 2. *Diseases Characterized by White Mucous Membrane Patches*

DISEASE	APPEARANCE OF LESIONS	COMMONEST LOCATION IN MOUTH	OTHER SITES INVOLVED	ASSOCIATED FINDINGS
Lichen planus	Reticular, lacelike or annular with normal islands of mucosa in between. Rarely painful erosion. Texture of mucosa normal. Rarely oral discomfort	Cheeks, tongue, lip, gingiva	50% show skin lesions on wrists, thighs, lower legs, genitalia	Itching, purplish to brown papular skin lesions
Leukoplakia	Leathery, irregularly shaped, yellowish or white, confluent. Texture of mucosa thickened and later fissured	Buccal mucosa along line of closure of teeth, tongue sides, palate (hard), floor of mouth		Friction, trauma, tobacco smoking; PRECANCEROUS LESION
Moniliasis	Irregular flaky white deposits which leave red surface after scraping off. Texture of mucosa normal	Tongue, palate, cheeks	Angular stomatitis	Genital or anal pruritus, avitaminosis
Lupus erythematosus	Circumscribed white patchy and red erosions which may heal with scarring. Texture normal or thinned	Lips, palate, cheeks	Face ("butterfly rash"), scalp, arms, neck	Acute types: febrile, joint stiffness, photosensitivity

TABLE 3. *Single Lesions of Lips or Tongue*

DISEASE	APPEARANCE	ASSOCIATED FINDINGS	METHOD OF DIAGNOSIS	COURSE
Erosive and Inflammatory				
Herpes simplex	Group of vesicles on inflamed base, soon become crusted, mild burning discomfort	Moderate regional lymph node enlargement		Spontaneous healing in 7–10 days, frequent recurrence
Pyogenic granuloma	¼–1 cm. diameter, red, easily bleeding or dark, crusted	Usually antecedent trauma		Rapid development common in children
Syphilitic chancre	Indurated, crusted erosion or nodule	Moderate non-tender lymph node enlargement	Darkfield exam. for *T. pallidum*	Heals in 3–4 weeks
Granulomatous				
Carcinoma	All may closely resemble each other; may show ulceration or diffuse infiltration. Size varies from ½ cm. to involvement of entire organ	Regional lymphadenopathy often marked (hard)	ADEQUATE BIOPSY IMPERATIVE FOR ALL	Gradual development over several months
Syphilitic gumma		Regional lymphadenopathy slight	Blood serologic test	
Tuberculosis		Regional lymphadenopathy marked	Culture for acid-fast organisms	
Warty				
Common wart	Superficial attachment; raised, pedunculated, or sessile; in mouth appears white		Excisional biopsy	Common in children with warts of hands; rapid growth, frequently multiple

SINGLE LESIONS OF LIPS OR TONGUE

The single lesions of the lip or tongue include some of the commonest and most important skin disorders, and often require biopsy and other laboratory methods for exact diagnosis. The dentist is in a uniquely favorable position for their detection and for securing ade-

Fig. 8. Fig. 9. Fig. 10.

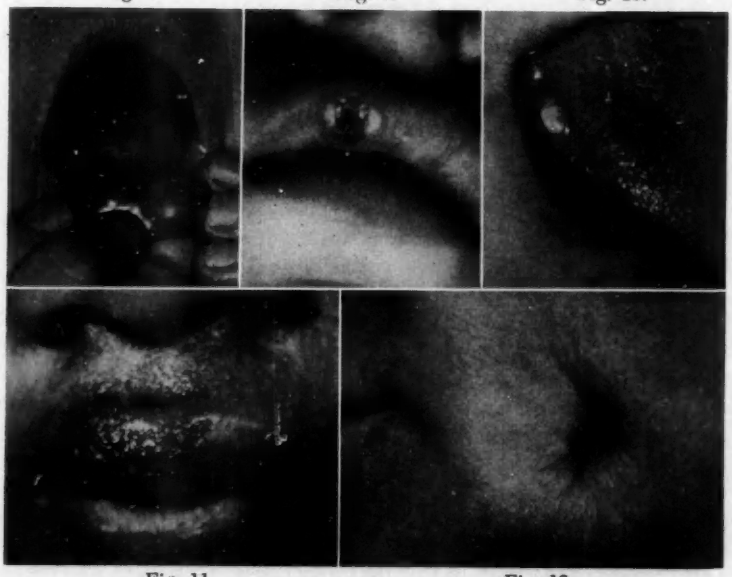

Fig. 11. Fig. 12.

Fig. 8. Pyogenic granuloma, lower lip.
Fig. 9. Syphilitic chancre, upper lip; 2 weeks' duration.
Fig. 10. Wart on right side tongue. White appearance is due to maceration of keratinous surface.
Fig. 11. Contact dermatitis of upper lip with swelling and vesiculation from cosmetic allergy.
Fig. 12. Sinus tract to left cheek of 3 years' duration, associated with abscessed molar tooth.

quate management for the patient. Table 3 gives some of the commoner lesions and their differential characteristics.

MISCELLANEOUS DISTURBANCES

Contact dermatitis (dermatitis venenata), or ***stomatitis*** (stomatitis venenata), is a local allergic reaction of skin or mucous membrane to surface-acting substances. It appears commonly on the vermilion

border of the lip and the adjacent facial skin, and probably somewhat less commonly on the buccal mucosa. The lip may appear dry, scaly and fissured, or red and swollen, with involvement of the surrounding skin areas (Fig. 11). In such cases dentifrices, cosmetics and foods (especially in children) should be carefully scrutinized. Patch tests can then be employed to determine the offenders. Involvement of the buccal mucosa may occur from diverse agents, notably flavoring substances of dentifrices, denture base materials, metallic alloys, or dental medicaments. The localization of the process will give clues to possible causes which can then be verified by the use of patch tests. The involved mucous membrane may appear simply reddened and hyperemic or may show more extensive damage by swelling, vesicle formation or ulceration.

Benign migratory glossitis (geographic tongue) is a common, recurrent, usually asymptomatic disorder of undetermined cause, found most often in children and young adults. It appears in the form of changing circumscribed gyrate patches on the tongue borders. The papillae are flattened in the center of the patches, which are bordered in yellowish white. Frequent remissions and exacerbations occur and spontaneous recovery is the rule. The differential diagnosis includes chiefly lichen planus and early syphilis.

"Fordyce's disease" is the term applied to a common variant of the oral and genital mucous membranes. It consists of few to many discrete yellowish, pinhead-sized papules, most often seen on the inside of the labial and buccal mucosa. These lesions represent aberrant sebaceous glands in areas where they are usually absent. They cause no symptoms and are of importance only because of their frequency and because of the concern that they may cause in a patient who tends to cancerophobia.

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Diseases of the Ear, Nose and Throat of Interest to the Dentist

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The cooperative efforts of well trained specialists such as the dentist and the otolaryngologist are imperative if we hope to solve some of the perplexing problems confronting us which are so intimately related to both specialties anatomically, physiologically and psychologically.

There are many diseases and pathologic conditions seen by the otolaryngologist in which the practicing dentist has more than a passing interest, and it is my desire to discuss some of these diseases from the practical viewpoint.

DISEASES OF THE EARS

It is common knowledge that conditions affecting the eustachian tube may produce auditory symptoms such as deafness, tinnitus, otalgia and vertigo. Many research workers have demonstrated that changes of pressure in the middle ear can reduce auditory acuity and that chronic contraction of the tensor tympani and stapedius muscles can reduce aural conduction. Lurie[5] found that chronic contraction of the tensor tympani reflex resulted in degeneration of the organ of Corti.

Studies by Goodfriend[2] and others were done on the temporomandibular joints of cadavers to demonstrate the relationship of various types of abnormalities of dental bite to the ears and eustachian tubes. These studies revealed that there is an intimate anatomic relationship between the temporomandibular joint, the external auditory meatus, the tympanic membrane, the tympanic cavity and the eustachian tube. It was also demonstrated that the nerve and the blood supply as well

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as the drainage of these parts of the ear pass between the temporomandibular joint and the ear.

These relationships are altered by abnormal bites which in turn alter the structure and movements of the temporomandibular joints. This causes injury, irritation, deformity and degenerations of the external auditory meatus, the tympanic membrane, the walls of the

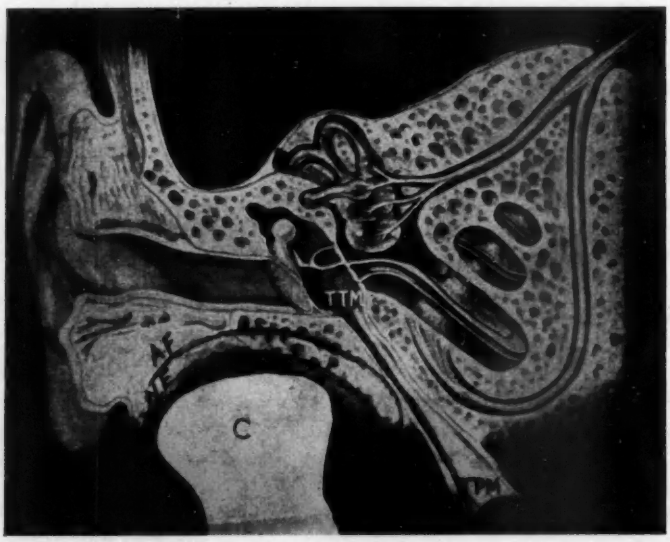

Fig. 1. A sketch of the ventral aspect of the mandibular joint–ear area showing the intimate anatomic relationships. The mandibular condyle, *C*, is the movable part of the joint of the jaws. The normal fossa is outlined by line *NF*. Abnormal dental bites cause various and progressive malrelations of the joint with displacement of the condyle and the fossa as shown by line *AF*. These altered relationships involve the inferoanterior walls of the external auditory meatus, the attachment of the tympanic membrane, the wall of the tympanic cavity and the lateral wall of the eustachian tube. They also involve the reflexes of the tensor tympani (*TTM*) and the tensor veli palantini muscles (*TPM*). (From Goodfriend, D. J.: Arch. Oto., *46*:1, 1947.)

tympanic cavity, the eustachian tube and the nerves and blood vessels that supply them.

Evolutional dental malocclusions are associated with evolutional malarticulation of the mandibular joints. Disease, attrition and loss of teeth, and unscientific restoration and replacement of teeth are associated with alterations of the normal anatomic relations and functions of the mandibular joints. These may cause resorption and degeneration of the articulating bone surfaces, displacement and trau-

matic movements of the condyles and degeneration of the fibrocartilaginous articular surfaces and of the meniscus. These changes have a profound influence on the adjacent aural structures including muscles, nerves, blood and lymph vessels.

A survey of school children in St. Louis revealed that 51 per cent had dental malocclusions. Goodfriend found 55 per cent dental maloc-

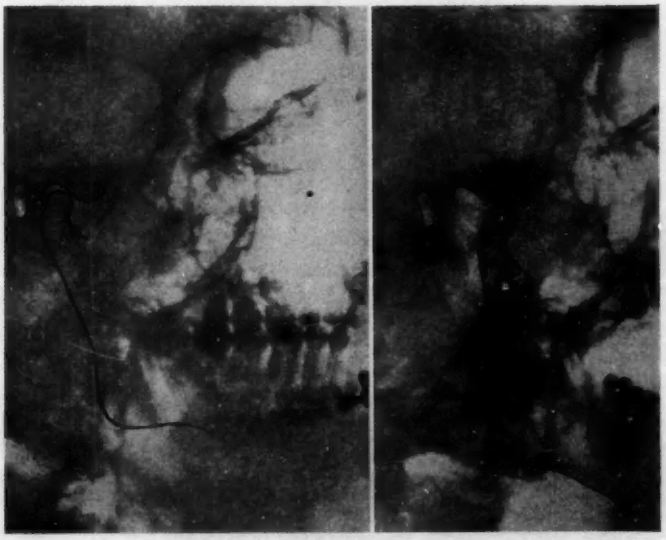

Fig. 2. Roentgenograms of the mandibular joint of a man aged 54 with a normal dental bite in the closed and the opened bite positions. This is a standard of normality, departures from which are variations of abnormality. (From Goodfriend, D. J.: Arch. Oto., *46*:1, 1947.)

clusions in his group of dental students, with 13 per cent greater hearing loss than in a normal group. Of patients with auditory complaints but no objective aural involvement, when examined in an otologic clinic, 92 per cent had dental malocclusion.

The proximity of the temporomandibular joint to the external auditory meatus and middle ear causes constant confusion as to the source of pain in this area. Stretching of the capsular or temporomandibular ligament during dental care may produce pain for several days that is referred to the ear. The pain associated with dental malocclusion is a reflex neuralgia due to impingement of the joint structures on the auriculotemporal nerve. Lingual symptoms may be reflex from irritated auriculotemporal fibers to the lingual nerve.

Sensation of obstruction to the ear is common and may be due

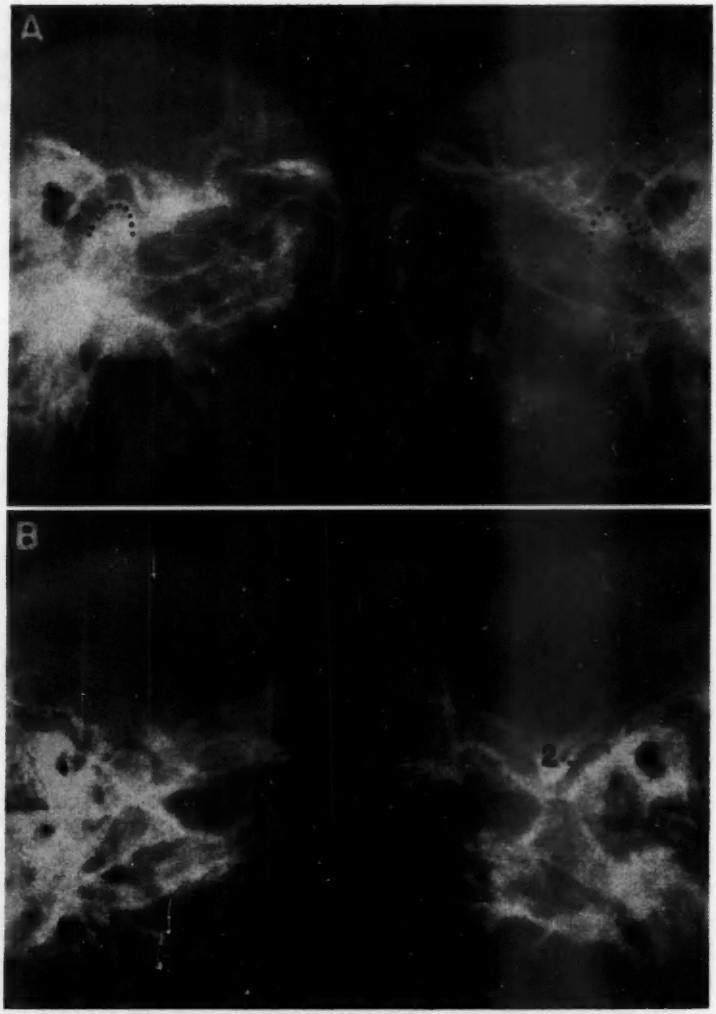

Fig. 3. *A*, Derangement. Derangements of the joints manifested as disturbances in the range of motion of the condyloid processes are relatively common and readily demonstrated on roentgen examination. Stereoscopic studies of the joints, with the jaws first closed and then opened, are necessary in order to study the range of motion of the condyles and their relation to the mandibular fossae and articular tubercles. Variations in these relationships depend on the nature of the derangement. In some cases the condyle on the involved side does not seat itself normally in the fossa or its excursion from the fossa is less than normal, as seen in *A*, where the movement of both condyles is limited. Greater limitation is noted on the side with symptoms, to the observer's left.

B, Arthritis. The manifestations of arthritis of the temporomandibular joints do

to overclosure of the jaw, causing bulging of the joint structures which impinge on and close the eustachian tube on its anterior membranous wall.

Of 26 patients with malocclusion studied by Staton,[10] only 3 complained of deafness although the audiogram was abnormal in 13. Tinnitus was present in 9 and in 10 there was a sensation of aural obstruction. Dizziness was noted in 5 patients.

In chronic pain, deafness or tinnitus suspected of being of temporomandibular joint origin, maximum information may be obtained by lateral stereoscopic projections of each joint with the jaws first closed and then opened. Derangements and arthritis may be found to be causing the aural symptoms.

If an accidental movement of the lower jaw, such as a blow to the jaw or a yawn, produces enough irritation within the joint, trismus and otalgia ensue. If the origin is an abscessed tooth or infection of the ear canal, removal of these sources of infection is the solution. If the joint changes are secondary to long-standing malocclusion and improper action of the condyle, irreversible changes in the meniscus, cartilage and bone structures of the joint occur. These tissues cannot be improved, but restoration of balanced occlusion usually removes the source of stress and damage so that pain and trismus are relieved. This latter type constitutes the largest fraction of the cases. In a series reported by Sanders,[8] 66 out of 75 were free of symptoms one year after occlusal restorations.

Subluxation of the joint has been treated by injecting sclerosing agents such as Sylnasal into the joint cavity.

Hydrocortisone has been proven to be the injection par excellence in cases of inflammation of the temporomandibular joint. Pirky[7] recently reported on 350 patients treated over a two year period. Pain was absent for an average of 5½ months, with only 14 of the series unimproved.

The presenting symptom in this group was pain. In 255 the pain was referred to the ear or the pre-auricular area; in 50 the pain was in the tongue and pharynx; in 35 the pain was in the lateral aspect of the neck, with radiation toward the ear. Various other symptoms were present, i.e., stuffiness of the ears, diminishing hearing, burning of the tongue, dryness of the mouth, etc.

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not differ from those noted in other joints of the body. The diagnosis is based on visualization of thinning of the cartilage zone (*B, 1*), demineralization of the articulating surfaces of the condyle and the fossa and roughening of the bony aspects of the joint. Comparison of the arthritic joint (*B, 1*) and the normal opposite joint (*B, 2*) emphasizes the changes due to disease. (From Young, B. R.: The Skull, Sinuses and Mastoids. Chicago, Year Book Publishers, Inc., 1948.)

Technique of injecting the temporomandibular joint: a 2 cc. syringe with a 22 or 25 gauge needle ¾ inch long is used. 1 cc. of the hydrocortisone is aspirated into the syringe. The joint is palpated and the area cleansed with alcohol. The patient is asked to open his mouth and the needle is inserted perpendicular to the mandible, ½ inch anterior to the tragus and ½ inch deep. The plunger is pulled back to be sure that the needle is in the joint capsule, and then 1 cc. is injected.

Cooperman and Willard[1] recently stated that improper jaw relationships may be the sole or contributing causes of many syndromes in and about the head and neck. They discussed a new diagnostic technique involving an appreciation of occlusal dynamics as the basis of physiologic appliances. Such disturbances as trigeminal neuralgia, severe headaches, trismus, loss of hearing, tinnitus, vertigo, clicking of temporomandibular joints and tics of the head and neck were relieved in 67 per cent of 71 patients by their combined use of occlusal dynamics, physiologic appliances and muscle therapy in malocclusion.

Aero-otitis media secondary to improper bite was the subject of an investigation by Kelly,[3] who treated 50 men who had symptoms of otitis media following tests in the pressure chamber. Correction of bite alone cured 46 of the 50 patients. He demonstrated conclusively that abnormalities of the dental bite may cause malfunction, edema and lymphatic stasis of the eustachian tube and resultant auditory conditions.

Cleft palate patients have been known to have a marked hearing defect, and in a recent study on the subject it was found that in 26 cleft palate patients, 62 per cent had a hearing loss greater than 10 decibels in one or both ears. No relationship was found between the hearing loss and the age of closure of the defect, and it was suggested that the only practical means of controlling and preventing hearing loss was prompt recognition and early treatment of all ear infections in this group of patients.

One of the most annoying and frustrating symptoms presented to the otolaryngologist is that of tinnitus, or a sensation of noise in the ear or head. There are three types of tinnitus, classed as vibratory, non-vibratory and cerebral. The vibratory type is often caused by dental pathosis and may vary from the sound of steam escaping to a buzzing, roaring or ringing sensation. Extraction of a molar tooth, with the associated edema and tissue reaction, may cause swelling around the eustachian tube producing tinnitus. Movements of the mandible in cases of chronic subluxation of the temporomandibular joints frequently cause clicking tinnitus. Improvement of the bite and the use of prostheses have done wonders in selected cases of tinnitus.

Attacks of vertigo may occur from dental abscesses that act as foci of infection and cause toxic labyrinthitis. The attacks persist as long as the infection is present and are usually controlled by removal of the offending tooth. Extractions of teeth which are infected frequently produce a bacteremia, and it is well in these instances to protect the patient with pre- and postoperative antibiotic therapy.

DISEASES OF THE NOSE

Any persistent obstruction to normal nasal respiration interferes with the proper development of the occlusive elements: the teeth, the alveolar arches and the muscles. Mouth breathers do not masticate properly, therefore the various structures do not grow harmoniously.

Some of the factors which the otolaryngologist sees frequently which influence nasal respiration and cause dental deformities are deviations of the nasal septum, deformities or hypertrophies of the turbinates, swelling of the mucous membranes due to allergy or chronic sinusitis, polyps and adenoids.

Most patients and many dentists are not aware of the fact that malocclusion and irregular development of the teeth are secondary to pathologic conditions in the nose or sinuses which are obvious to an otolaryngologist, and which may be amenable to relatively minor surgery or treatment. A properly done submucous resection of the nasal septum can make a tremendous difference in the nasal airways when this operation is indicated. The reason this procedure has fallen into disrepute is that many patients with nasal obstruction were subjected to this operation without relief because the fundamental pathosis causing the obstruction was nasal allergy which was either not suspected or not properly treated.

Most cases of intermittent nasal stuffiness with postnasal drip, frequent colds with a partial loss of hearing, constant irritation of the pharynx with hypertrophied lymph follicles on the posterior pharyngeal wall, non-productive cough and recurring attacks of hoarseness are on an allergic basis, and the dentist should be cognizant of this common disease entity which causes chronic nasal obstruction with resultant dental pathosis.

DISEASES OF THE MAXILLARY SINUSES

There has been a great deal of variation in the estimation of the part played by dental infections of the upper jaw in the pathogenesis of maxillary sinusitis in the past fifty years. Originally the importance of these infections in causing sinusitis was exaggerated, and now the

pendulum has swung to considerable underestimation. About 10 per cent of all maxillary sinus infections are of dental origin.

Dental infections may exist for years in close apposition to the floor of the maxillary sinus without extension to the sinus mucosa. Every untreated infection of a tooth or its supporting soft tissue ultimately leads to infection of the surrounding bone. From the point of view of the spread of sepsis, the infection of the bone is the important factor.

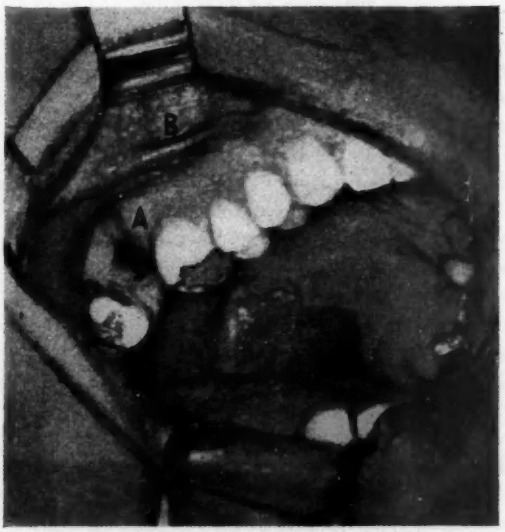

Fig. 4. An opening into the maxillary sinus of six weeks' duration which followed removal of a second molar. The edges of the mucous membrane are turned in. The gum tissue at *A* is inelastic and strongly adherent to the bone. The folds of mucous membrane at *B* are flexible and elastic. These folds of tissue can be displaced to advantage only after the periosteum has been released. (From Berger, in Van Alyea, O. E.: Nasal Sinuses. 2nd ed. Baltimore, Williams & Wilkins Co., 1951.)

Residual chronic osteitis may remain in the jaw bone many years after infected teeth which produced it have been removed. Most clinicians regard an edentulous jaw as being free from infection, but it is interesting to note how frequently roentgenograms of apparently healthy edentulous jaws reveal retained tooth roots, chronic osteitis and infected cysts. Of 52 cases in a recent study of the relationship between infected teeth and maxillary sinusitis, specimens taken from the sinus mucosa near the infected teeth showed pathologic changes in every case with thickening of the mucosa, and frequently there was pus present.

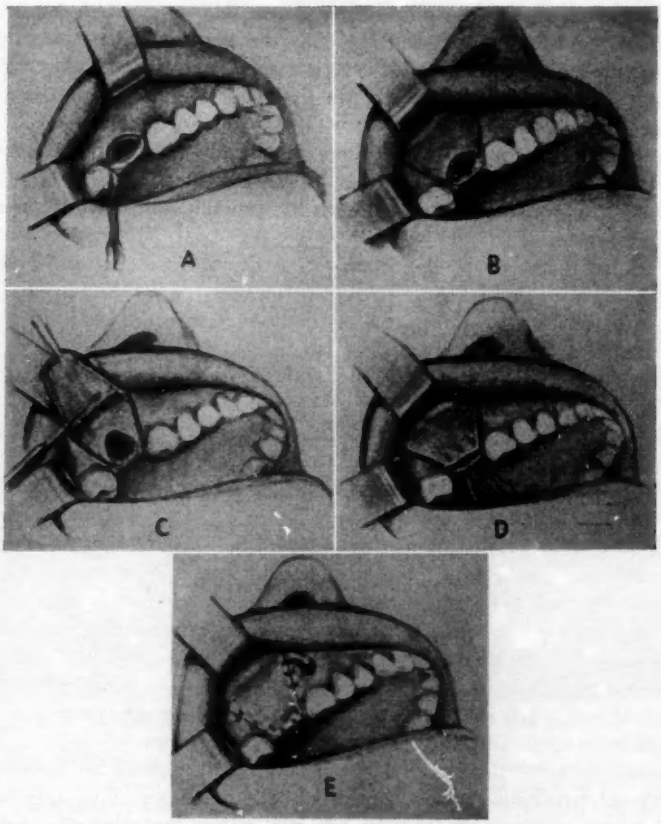

Fig. 5. Berger's sliding flap technique. *A*, First step of the operation. The edge of the opening is excised, and the vivified surface is secured. *B*, Two divergent incisions are carried from the extreme edges of the opening into the folds of tissue. *C*, The flap is raised and the bony opening made large enough for inspection and for removal of the diseased contents of the sinus. Several horizontal incisions are made through the periosteum, as indicated with the scalpel. *D*, The flap is trimmed to meet the palatal edges of the opening, and mattress sutures are introduced over the area where bone is lacking to secure definite coaptation. *E*, The mattress sutures are reenforced, and closing is completed, with interrupted sutures. The end of the iodoform gauze is shown protruding from the uppermost part of the wound. (From Van Alyea, O. E.: Nasal Sinuses. 2nd ed. Baltimore, Williams & Wilkins Co., 1951.)

Empyema of the maxillary sinus often follows curettement of a tooth socket after extraction, or it may develop when the sinus floor is fractured even though great care is exercised in the extraction. The most commonly involved teeth are the second premolar or the first and second molars.

Antral infections of dental origin are usually identified by a foul-smelling nasal discharge. There is usually no pain unless there is an extension of the infection to involve the ethmoid and frontal sinuses on the infected side.

The treatment of choice is irrigation through the natural ostium of the sinus or by a needle puncture through the inferior meatus of the nose, but never through the fistulous tract. It is advisable to have the irrigated secretion, which is usually purulent, sent to the laboratory for culture and sensitivity tests so that treatment with the proper antibiotic may be started promptly. We are seeing many organisms present in sinus infections, particularly the staphylococci, which have become resistant to the commonly used antibiotics so that it is important to have cultures and sensitivity studies made for specific therapy in this type of infection.

Occasionally in persistent antral infections an intranasal window operation or antrostomy must be done, but rarely do these infections require the radical Caldwell-Luc procedure.

Fistulae between the antrum and oral cavity occur rather commonly following the extraction of teeth which have roots close to the antral floor. Occasionally the antral floor is penetrated by extensive curettement of the tooth socket by the dentist, or by the application of too much force in packing the socket with gauze or cotton.

Antral-alveolar fistulae, if large or persistent, should be closed by a plastic procedure, after control of the maxillary sinus infection. There are many techniques used, but failure to close the fistula may be due to lack of care in removing areas of osteomyelitis present in the alveolar process. Berger's sliding flap technique has been used by many with success.

LESIONS OF THE MOUTH

The mouth provides the dentist and the otolaryngologist alike a rare opportunity to observe early findings of systemic disease.

Nutritional disturbances, whether due to improper intake of food or its improper utilization in the body, promptly reflect themselves in the mouth. Riboflavin deficiency reveals itself in fissures at the angles of the mouth and a glossitis confined to the tip and margins of the tongue. Niacin lack causes redness and occasionally ulceration

on the sides and tip of the tongue as well as redness and swelling of the gingival and buccal mucosa. Vitamin C deficiency produces scurvy, which is characterized by swelling and redness of the gingiva, ulceration around the teeth and a foul breath. These deficiencies are best overcome by parenteral administration of the appropriate vitamin.

Blood dyscrasias frequently display early manifestations in the mouth. Petechiae, spontaneous hemorrhages and ulceration of the

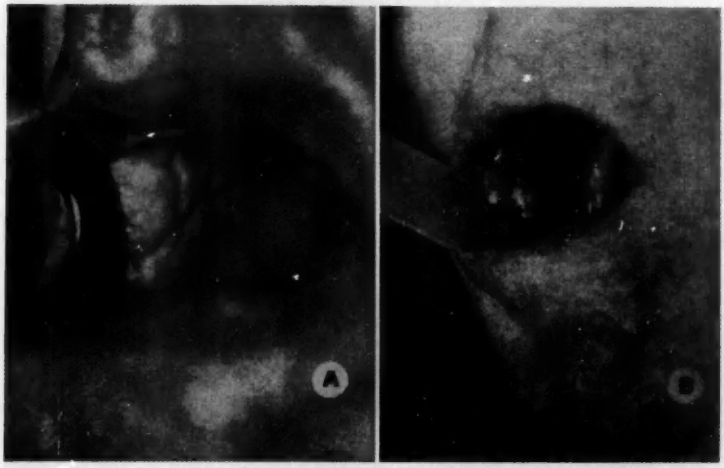

Fig. 6. *A*, Leukoplakic spot on right buccal mucosa for several months. On histologic study, no cancer was found. *B*, Patient returned 4 years later with squamous cell carcinoma in the scar. (From Ward, G. E., and Hendrick, J. W.: Diagnosis and Treatment of Tumors of the Head and Neck. Baltimore, Williams & Wilkins Co., 1950.)

buccal or pharyngeal mucosa should make one suspicious of leukemia, agranulocytosis, thrombocytopenia or severe anemia.

Diseases of the endocrine glands often reveal themselves in lesions of the mouth. In Addison's disease one may see brown pigmented areas on the lips, gingiva, buccal mucosa and the tongue. Myxedema causes a thick tongue, while hyperthyroidism produces a fine tremor of the tongue. The muscles of the mouth and pharynx become easily fatigued in myasthenia gravis.

The well informed dentist recognizes many of these lesions and refers these patients to his medical colleague for appropriate therapy.

The widespread use of antibiotics has produced many cases of moniliasis of the buccal and pharyngeal mucosa. It manifests itself in the form of small milklike flakes in these areas. These lesions are

usually not painful but respond rapidly to Heliogen,[9] a nascent iodine used as a mouth wash or gargle three times daily. Mycostatin, a fungicidal antibiotic, may be used internally.

A tongue lesion which is being seen more frequently since the advent of antibiotic therapy is black hairy tongue. The dorsum of

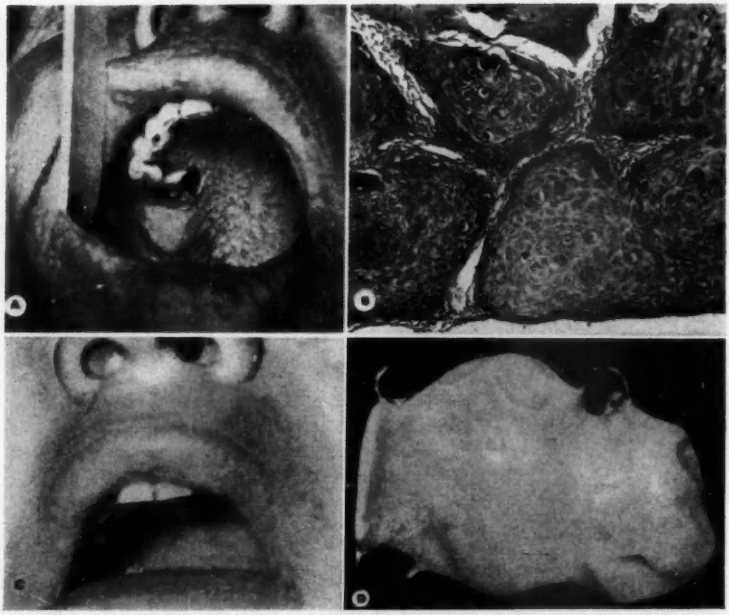

Fig. 7. *A*, Squamous cell carcinoma, right upper alveolus. Note elevated edges of the ulcer, distinguishing it from an inflammatory process. Also notice the leukoplakia extending over the hard and soft palate. This is of the chronic type with craters in the center of which are tufts of capillaries, causing bleeding in some cases. *B*, Highly differentiated squamous cell carcinoma, the type that arises in leukoplakia. *C*, Defect in superior maxilla following irradiation and electrosurgical removal. *D*, Prosthesis with obturator filling the upper surface of the defect, allowing normal eating and talking. (From Ward, G. E., and Hendrick, J. W.: Diagnosis and Treatment of Tumors of the Head and Neck. Baltimore, Williams & Wilkins Co., 1950.)

the tongue anterior to the circumvallate papilla is covered with brownish black, hairlike, hyperplastic filiform papillae. It is cured by scraping off the elongated papillae with a tongue depressor and stopping antibiotic administration.

Welch[12] states that 3500 deaths from oral cancer can be prevented each year by prompt diagnosis and appropriate therapy of precancerous lesions. More than 50 per cent of all carcinoma of the mouth

can be eliminated in the precancerous stage and half of the remainder can be cured by surgery.

Most authorities agree that leukoplakia of the mouth and tongue are precancerous lesions. The consensus today is that the most common oral lesion resulting from one or more forms of mild, long-standing chronic irritation is leukoplakia. Some evidence of the disease can be demonstrated in 50 per cent of all men and about 10 per cent of all women over 45 years of age. The frequent use of tobacco and alcohol is an etiologic factor in the production of leukoplakia.

The relationship between chronic irritation and decayed, sharp, broken teeth, accumulated calculus and poorly constructed dental replacements is established. Fillings and dentures become rough unless properly cared for, and dental neglect may result in cavities which cut the adjacent mucosa.

Leukoplakia may result from local electric trauma, inasmuch as the saliva is a good electrolyte and there is a constant flow of current between any restorations such as dentures, plates and fillings of different electropotential.

Marchetta and Mattick[6] recently reported their observations on 247 patients with carcinoma of the tongue. They pointed out that approximately 20 per cent of the lesions were on the lateral part of the tongue and 10 per cent at the base of the tongue. Dentists in their routine examinations should be cognizant of these figures and look for early malignant lesions, because the policy of educating the public to see a dentist twice a year gives the profession an unusual opportunity to discover suspicious lesions early. The early carcinomas are the only ones that can be cured.

DISEASES OF THE THROAT

The discomfort of a unilateral sore throat or pharyngitis, especially in a young adult, may have as its etiology a pericoronitis, or inflammation about a partially erupted third molar. Infection arising from such lesions may also restrict movement of the mandible and cause severe pain. The infection may spread to involve the pterygomandibular space, i.e., the space between the mandible and the internal pterygoid muscle, or it may spread to involve the parapharyngeal space, i.e., the space between the internal pterygoid muscle and the superior constrictor of the pharynx, or the infection may involve the area between the two connective tissue layers surrounding the parotid gland. It is important to know of these possible complications so that they may be promptly and properly drained.

Inflammation or hemorrhage within the internal pterygoid muscle

may occur as a result of the use of local anesthesia in a mandibular block.

Dental foreign bodies may occasionally be aspirated into the air or food passages. Gauze packs or dental appliances accidentally lodging in the larynx can cause asphyxia, and the dental surgeon, particularly if he is operating under general anesthesia, should know the fundamentals of a tracheotomy. Aspirated teeth or parts of teeth account for the largest number of dental foreign bodies. Roentgenographic evidence is helpful in locating dental objects, but unfortunately not all of them are radiopaque.

Virtue[11] reported on 37 patients with carcinoma of the tonsil. He stated that two-thirds of them had easily demonstrable lymph nodes in the neck when they were first examined. Pain and throat irritation, usually on one side, were the outstanding symptoms. The area is supplied by the ninth cranial nerve, and pain may be transmitted by the fifth, seventh and tenth cranial nerves and the upper three cervical nerves. One-third of the patients had been treated with gargles, antibiotics and tooth extraction for pain before the primary lesion was discovered in the tonsil.

The treatment for carcinoma of the tonsil is intensive radiation after biopsy.

Inasmuch as the diagnosis of malignancies of the nasopharynx, tonsil, pharynx and tongue is being made more frequently today and most authorities agree that supervoltage radiation or cobalt therapy is the treatment of choice, we are seeing more radiation necrosis of the soft tissue of the mouth as a consequence.

It has been shown that avascularity, necrosis and infection symbolize the sequence of events in radionecrosis. The difference between a "tumor lethal dose" and that which will produce necrosis is very small.

Necrotic lesions of radiation necrosis start in irradiation scars with erythema and tenderness which spread to involve what has previously been healthy tissue. It is interesting to note that 50 per cent of all breakdowns develop more than 2 years after the conclusion of radiation therapy.

The lesions are very painful and the first step in treatment is to alleviate the pain. This is done by covering the lesion with an appliance under which is placed medication with analgesic and bactericidal properties. This method was suggested by Klock.[4] Antiseptic and analgesic mouth washes are prescribed. An aqueous solution of 5 per cent urea has been found to be efficacious.

Irradiation epithelitis is not uncommon following intensive radiation therapy for tumors of the larynx, soft palate, tongue or tonsil. The

mucous membranes of the mouth and soft palate become edematous, and vesiculation and ulcers may form. Epithelitis of this degree is extremely painful, and in some instances even a liquid diet is difficult to manage. Elixir probutylin is an excellent local anesthetic to use in the mouth for these painful lesions.

SUMMARY

1. There is an intimate anatomic and physiologic relationship between the temporomandibular joint and the structures of the external ear, middle ear and the eustachian tube.

2. Inflammatory lesions of the temporomandibular joint as well as malocclusion and other forms of trauma frequently produce aural symptoms such as deafness, tinnitus, otalgia and vertigo.

3. A high percentage of aural symptoms secondary to an improper bite can be relieved by restoration of a balanced occlusion using the newer techniques for diagnosis and treatment.

4. Nasal obstruction is a common cause of dental abnormalities whether due to adenoids, deviated nasal septum, chronic sinusitis, nasal polyps or allergic rhinitis.

5. Maxillary sinusitis is of dental origin in approximately 10 per cent of the cases.

6. Empyema of the maxillary sinus following the extraction of a tooth should be irrigated either through the natural sinus ostium or through the inferior meatus of the nose but never through the fistula.

7. Maxillary sinusitis of dental origin should be cultured for sensitivities and treated with the appropriate antibiotic.

8. The mouth is frequently the site of early lesions of systemic diseases such as vitamin deficiencies and other nutritional disturbances, blood dyscrasias and endocrine gland abnormalities.

9. Leukoplakia in the mouth is generally regarded as a precancerous lesion and is often secondary to chronic irritation from tobacco, alcohol, broken teeth, cavities, fillings and improperly fitted dentures. Cancer can be prevented by eliminating these irritating factors.

10. Pericoronitis can spread infection to the pterygomandibular and the parapharyngeal spaces in the throat, causing serious complications.

11. Radiation therapy of tumors of the throat and neck produces early changes in the mucous membranes of the mouth such as epithelitis and late lesions in the form of radiation necrosis. Both of these reactions are a challenge to the dentist in his care of the mouth.

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Clinically Observed Oral Manifestations of Endocrinopathy

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The relationship of extrinsic, genetic and endocrine factors to growth and development is a very complex, indefinitive study of which much yet remains to be clarified.

The over-all function of the endocrine glands—thyroid, parathyroids, pituitary, gonads, adrenals, pancreas—is that of catalysis,[15] that is, acceleration or retardation of basic enzyme systems within the cells themselves.[22] It is probable that no hormone has a direct independent action.[22] Furthermore, the effects of endocrine secretions on the human dental structures are restricted according to factors of time, intensity, and duration of the action. Undoubtedly genetic factors, congenital and acquired defects, infectious diseases, and nutritional deficiencies exert their influences on the dental structures to a much greater degree and frequency than do those of purely endocrine origin. Of all the endocrines, the thyroid gland seems to be the most clearly related to development and rate of eruption of teeth.[11]

DISORDERS OF THE THYROID GLAND

The thyroid *primarily* regulates the rate of cellular oxygen metabolism and metamorphosis, and *secondarily* affects growth and development.

Hypothyroidism

In congenital hypothyroidism or infantile myxedema, dental alterations, as other physical and mental changes, may be striking. Retarded growth of the skull results in a small arch, with a tendency

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toward crowding and malalignment of the erupted teeth. The eruption of the teeth is greatly delayed, as is the exfoliation of the deciduous teeth. Bone development is retarded to an outstanding degree, and produces the typical facies of the cretin: an open bite, a receding chin, and a large protruding tongue (Fig. 1).

The consensus has been that there is no direct increase in susceptibility to dental caries that is associated with this disorder, and it has been presumed that malnutrition and poor oral hygiene are highly

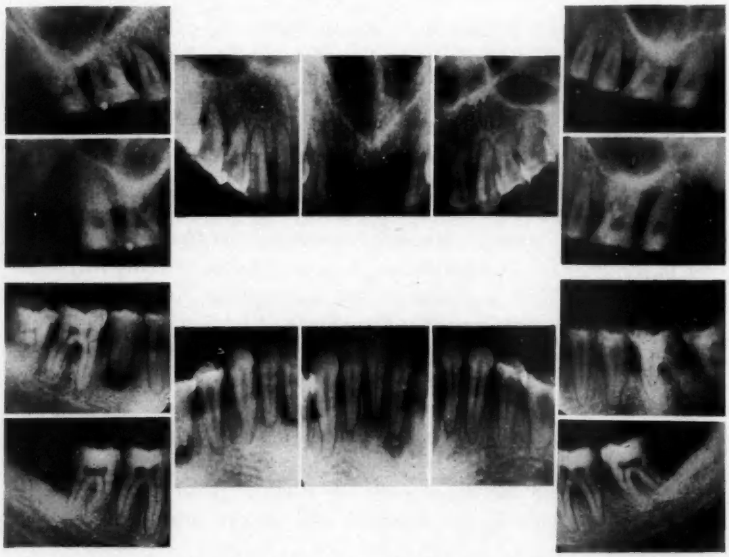

Fig. 1. Cretinism, hypo-ovarianism, mental deficiency. Female, age 21 years.

important factors associated with thyroid dysfunction. In the patients that I have observed, despite their malocclusion, the incidence of caries was low, probably because of their improved nutritional status and carefully supervised oral care. The delayed eruption of the teeth was the principal dental abnormality.

In the hypothyroidism of childhood, designated as juvenile hypothyroidism, the condition is usually not severe and is amenable to treatment. The child has a normal intellect and no noticeable impairment of physical activity. The first observations of thyroid deficiency may be made by the parent, who observes a lack of normal rate of growth, or by the family dentist, who notes a delay of eruption of teeth or retardation of exfoliation of deciduous teeth, with a tendency to crowded malocclusion of the anterior segment of the jaw with

slight-to-no progressive spacing of anterior deciduous teeth. Factors other than endocrine must be considered also, and are probably much more commonly the cause. Tager,[18] in his study of special orthodontic problems of 100 children, found only 10 who showed frank endocrinopathy; nine of these were hypothyroid.

In adult myxedema there is no apparent direct influence of hypothyroidism on the teeth and their supporting structures. Those dental abnormalities that were noted could well be considered to be related to the patient's age and nutritional state. Becks[1] noted a high percentage of periodontosis in adult myxedema. Lewis[9] reported an improvement of the periodontal condition after treatment of myxedema.

In reviewing case histories of 143 patients with adult myxedema seen at the Cleveland Clinic, there were 38 in which complete dental histories were recorded. Of the 38 patients, 26 showed little or no periodontal disturbances, while 12 had a moderate-to-marked degree of periodontal disease. Eighteen patients had a marked susceptibility to dental caries.

Hyperthyroidism

Graves' disease is a type of hyperthyroidism, also known as thyrotoxicosis, Basedow's disease or exophthalmic goiter. This accelerates the eruption of the teeth and the exfoliation of deciduous teeth. It is rare in children, and with early treatment the effect is brief.

Welti[21] reported a 5 year old child with a bone age of from 10 to 12 years and a dental age of 9 years. The deciduous teeth had been exfoliated at the age of 3½ years. Our observation includes two children with diffuse goiter and hyperthyroidism who had early eruption of the teeth. One child was seen at the age of 4½ years, five months following thyroidectomy, in whom the deciduous teeth were stated to have erupted at five months of age. At the time of examination the lower central incisors of the second dentition and the six-year molars were erupting. There was severe caries of the deciduous teeth, which were discolored and showed growth diastema. Roentgenograms were not obtained at that time. Six years later the patient, aged 10 years and two months, had all permanent teeth erupted except the 12- and 18-year molars. The 12-year molars appeared ready to erupt; root formation was well toward completion. The 18-year molars had begun to calcify. Tooth formation, shape and size of teeth, and occlusion were normal. Susceptibility to caries was moderate; there were restorations in seven teeth. There was some

osteoporosis of the supporting bone structure with a fine trabecular pattern.

The second child, aged 10 years, having a diffuse goiter with hyperthyroidism, also had an early eruption of normal-sized teeth. The roots of these teeth appeared to be long and thin. The incidence of caries was low and was confined to the remaining deciduous teeth. The arches were narrow and there was slight malocclusion.

Periodontal disease is thought to be associated with hyperthyroidism; however, this relationship has not been firmly substantiated by teams of investigators.[15] Our clinical observations reported here concern six patients whose ages were from 39 to 67 years. All six showed extensive oral neglect; three showed advanced periodontal disease and three showed little or none. Five showed an extreme susceptibility to caries. One patient with an associated diabetes had slight caries and advanced periodontal disease with considerable calculus. It should be stated that this observation is limited to the few who had a concomitant dental problem. However, one may be impressed, in reviewing the case histories of those patients with this disorder, by the great number who are edentulous.

DISORDERS OF THE PARATHYROID GLANDS

The parathyroid glands have some association with the calcification of teeth. They play a leading role in regulating the blood calcium and phosphorus concentration, the excretion of these elements, and thus the maintenance of bone structure. They do not affect the dimension of the teeth; general formation may be affected through hypoplasia of the enamel, and such conditions have been reported.[22] They have little or no direct effect upon the growth or eruption of the teeth.

Hyperparathyroidism

Hyperparathyroidism can cause striking changes in the dental supporting structures of the bone. The trabeculae become "lacy"—fine and closely meshed. With increased severity of the condition, osteoporosis and cystic formations develop. In some cases, giant cell tumor formations have been shown to be present with evidence of root resorption of approximating teeth. The disappearance of the lamina dura of the alveoli is considered pathognomonic for hyperparathyroidism, but does not invariably accompany the disease. In my experience the disappearance is largely confined to those areas that were under the mechanical stress of abnormal mastication. Stafne[17]

points out that roentgen evidence includes the disappearance also of the radiopaque lines of the lamina dura representing the borders of the maxillary sinuses, nasal fossae, alveolar crests and the wider crests of the inferior and lateral borders of the mandible. These changes occur after a long duration and unusual severity of the disorder. However, after the hyperparathyroidism has been controlled, the lamina dura re-forms.

Although the bone structure decalcifies, the teeth remain well calcified and may even show increasing calcification. The roots of the

Fig. 2. Hyperparathyroidism. Male, age 17 years.

teeth appear spindle-shaped.[17] Caries activity is not increased. The teeth may or may not be loose, but do have a tendency toward drifting and accelerated malocclusion (Fig. 2).

Hypoparathyroidism

In hypoparathyroidism, hypoplasia of the enamel and dentin has been described. Our experience in the human has been limited to a single patient and her children.

The patient was a young woman aged 25 years who had had undiagnosed hypoparathyroidism with tetany over a stated 12-year period. During this time she had married and had four uncomplicated pregnancies. The family economic level was low, and protein

and fruit intake was nearly negligible. When examined, this patient had all except 6 teeth, and no hypoplasia of the dental enamel. The third molars were unerupted, but there was adequate space for them. There was marked oral neglect, the teeth being covered with soft materia alba. Susceptibility to dental caries appeared slight. The bone tissue was well calcified with distinct lamina dura of the alveoli. The roots of the upper bicuspids appeared to be somewhat stunted.

The teeth of the four children born during this period of hypoparathyroidism of the mother showed no great abnormalities in dental shape or size; there was no hypoplasia of enamel. The alveolar bone of the eldest, aged 10 years, showed some osteoporosis, and the lamina dura and trabecular pattern were not prominent. There was a class III prognathism with evidence of oligodontia associated with the bicuspid teeth of the second dentition. No carious defects were in the permanent teeth, but deep pits of inadequate calcification were on the occlusal surfaces of the molars. The second child, aged 9 years, also had a malocclusion of end-to-end type; the deciduous teeth were carious. The third child, aged 7 years, had normal occlusion, badly carious deciduous molars; and the upper central incisors, on roentgen inspection, appeared to have subcalcification of dentin of the crowns as evidenced by indistinct pulp chambers and thin enamel caps. The fourth child, aged 5 years, had some malocclusion; of the 18 deciduous teeth present, 4 were carious; the lower six-year molars had erupted. The fifth child, who had been carried during the active treatment phase of the mother which continued throughout that pregnancy, had, at the age of 22 months, normal occlusion of 16 deciduous teeth and no evidence of dental caries.

DISORDERS OF THE PITUITARY GLAND

Pituitary dysfunction is manifested in the supporting dental structures, particularly of bone. The activity of the anterior lobe, which regulates, among other functions, rate of growth, is of some importance to the dental structures. Normally the period of life during which the pituitary growth hormone is most important is prior to cessation of total body growth. It exerts influence on other glands of the endocrine system, chiefly the target glands—thyroid, adrenals, and gonads. Thus, dental variation associated with the thyroid gland may have its origin in pituitary dysfunction.

Hypopituitarism

In hypopituitarism the pituitary deficiency decelerates the growth of all tissues. In pituitary dwarfism, the face is small compared with

the cranium, and the paranasal sinuses are undeveloped. The teeth are of normal shape and size, but eruption is retarded and shedding is delayed, probably partially through the secondary effects of hypothyroidism. With insufficient increase in vertical dimension and arch length there results a crowding and submerging effect on the teeth. Thus, the clinical crown may appear smaller, and the roots, although fully formed, may be shorter and have small pulp canals. Increased calcification with sclerosis of dentin and bone has been reported.[15]

Fig. 3. Pituitary dwarfism. Male, age 16 years.

The reduction of condylar growth results in a malrelationship of mandible to maxilla which further accentuates the infant mandible.[15]

In one patient aged 12 years the dentition was that of an 8 or 9 year old; teeth were crowded and some caries was present. When the patient was 19 years old, there still was considerable malocclusion, with crowded teeth that were normal in size and shape. Two upper bicuspids were unerupted. The bone age was stated to be between 12 and 13 years. There was no increase in incidence of dental caries or of periodontal disturbance (Fig. 3).

Froelich's syndrome is a condition in which there is pituitary deficiency in gonadotrophic hormone, with secondary hypogonadism and associated obesity. In the classic condition as originally described

there is also a suprasellar neoplasm. In its true form the syndrome is very rare. The diagnosis is sometimes applied, often erroneously, to obesity of adolescence with suspected delay in puberty.

One young adult who supposedly had Froelich's syndrome had never had previous dental consultation or care. He had 32 teeth in perfect occlusion without a carious lesion or restoration; the teeth were well formed and of normal size. There was no stain or calculus formation. Another patient who supposedly had Froehlich's syndrome and hypothyroidism had all permanent teeth present except for delayed eruption of an upper anterior tooth. Thyroid medication was begun and within three months prompt eruption of this tooth occurred. All of the teeth were or normal size and shape, and there was evidence of a moderate degree of carious activity. The dental status of such patients would appear to be usually better than average.

A third patient with hypopituitarism, hypo-ovarianism and mild hypothyroidism had teeth that were somewhat small in size, and there was oligodontia of the upper lateral incisors. There was malocclusion of a prognathic type that suggested maxillary retrusion with a high palatal vault. Rampant caries was present along with rapid accumulation of calculus and stain.

Hyperpituitarism

In hyperpituitarism with an excess of growth hormone there results a state of gigantism in the child, with an overgrowth of the skeletal system (Fig. 4). This is characterized by a growth of relatively uniform proportion and an over-all increase in the absolute skeletal size, especially in body height. With the onset of symptoms, rarely before the age of 6 years, the crowns of the teeth of the second dentition are not affected as to variation in size although the rates of eruption and exfoliation appear to be increased. The dental course is one of normal-sized teeth that erupt early, and increased growth of the jaws produces spaced teeth in large jaws with no disproportion in occlusal relationship.

In acromegaly or hyperpituitarism of the adult the growth of the jaw through the condylar head continues, producing prognathism with marked obtuse angulation of the jaw. With the supra-eruption of the teeth there is also produced a marked overgrowth of the alveolar process.[15] The roots of the teeth show hypercementosis. The teeth, of normal size and shape, are spaced with a characteristic labial fanning of the lower incisors which has been pointed out by Korkhaus[7] as pathognomonic for the disease, and as probably resulting directly from the enlargement of the tongue (Fig. 5).

Fig. 4. Hyperpituitarism: gigantism with hemihypertrophy (unilateral, right side). Male, age 15 years.

Fig. 5. Acromegaly. Male, age 45 years.

DISORDERS OF THE GONADS

Hormone secretions from the testes and ovaries control growth of sexual organs and secondary sexual characteristics. These hormones limit the effect of the growth hormone of the pituitary, thereby affecting maturation of the bone epiphyses. They probably have no direct effect upon human teeth. In animals, disturbance in dental calcification has been reported after gonadectomy.[12] Inasmuch as hypogonadism cannot be diagnosed early and as the function of these glands is activated at puberty, their activity associated with human dentition is difficult to assay. Hypogonadism associated with hypopituitarism has already been commented upon.

DISORDERS OF THE ADRENAL GLANDS

The adrenal secretion has no apparent direct effect upon the human dental structures. Extirpation of the adrenals in animals causes disturbances in dentin calcification.

Hypoadrenia (Adrenal Insufficiency)

Hypofunction of the adrenal glands results in Addison's disease, a wasting disease characterized by lassitude and by hyperpigmentation of the skin and oral cavity. The dental signs may be an early manifestation: the oral mucosa is pale with a brownish cast, or pigmented with macules. As the disease progresses, the deterioration would seem to be reflected in the dental structures by an increasing susceptibility to caries and advancing periodontal disorder. Disturbances necessitating dental surgery must be regarded with concern, in view of an easily precipitated adrenal crisis with fatal termination.

Hyperadrenocorticism

Hyperadrenocorticism (adrenocortical hyperfunction) is recognized in three forms: Cushing's syndrome, adrenogenital syndrome, and primary aldosteronism.

Cushing's syndrome is characterized by marked osteoporosis, among other changes. Levine and Weisberg[8] reported the occurrence of osteoporosis in 64 per cent of all females and in 75 per cent of all males in 51 cases. The incidence of osteoporosis in the jaws is not known.[17] Stafne[17] described a uniform osteoporosis of the maxilla, of the mandible with partial obliteration of the cortices, of the lamina dura, and

of the borders of the maxillary sinus with no great transformation of the trabecular pattern. With the factors of constitutional patterns, mechanical stress, and infection, this alteration of the jaws is difficult to assess.

Adrenogenital syndrome in childhood produces pubertas precox, which is due to functional hyperactivity of the adrenal cortex or to a tumor. Early signs of puberty are noted; however, precocious dental development does not follow any accelerated bone growth and advanced epiphyseal maturity. In these instances the dental age parallels the chronologic age. There are no changes in form or size of teeth; the occlusion may be normal and there is no increased susceptibility to dental caries.

Primary Aldosteronism. In this disturbance of potassium metabolism, dental findings have not been recorded, to my knowledge, and I am unfamiliar with the dental picture. In three case histories reviewed, a beefy red tongue was reported in one and in another the primary complaint was of throat trouble for a three year period (detailed as "sluggishness"). This latter patient was edentulous.

DISORDERS OF THE PANCREAS—DIABETES MELLITUS

The pancreas has been included with the endocrine glands though it has primarily an exocrine function concerned with the process of digestion. The endocrine function, acting through the islets of Langerhans, is concerned with carbohydrate and fat metabolism. With the secretion of insulin by the beta cells, the glycogen storage in the liver and muscles is regulated along with its mobilization and combustion for use as an energy agent. There is no apparent direct effect of this agent upon the dental structures. In passing, mention should be made that diabetic dwarfism does exist, but is seldom seen nowadays. It is indistinguishable from pituitary dwarfism except for the diabetes itself. The effect of this condition upon the dental structures has not been recognized. Diabetes mellitus resulting from hypoinsulinism results in a disturbance of carbohydrate, fat, and protein metabolism. This alteration of metabolism seriously affects nutritional function and probably has considerable secondary effect upon the dental structures.

The teeth and jaws of juvenile diabetics show normal development (Fig. 6). Young persons have been reported to show no changes in supporting bone around the teeth;[14] when changes do occur, the early site appears to be the lower incisor region. Observers[5] have reported that the dental caries was less advanced in diabetic children than

would be expected in the general population, and this was attributed to rigid dietary control.

In adult diabetes, increased periodontal disease[10] has been noted. Several reasons have been advanced for this: marked debility and nutritional disturbances cause lowered tissue resistance and a greater tendency toward a rapid, virulent infection of tissues; a concomitant poor state of personal care is also a factor.[2] Charges in bony structure of the nature of osteoporosis with secondary infection have been noted.[4] Degenerative change in walls of the blood vessels with arterial

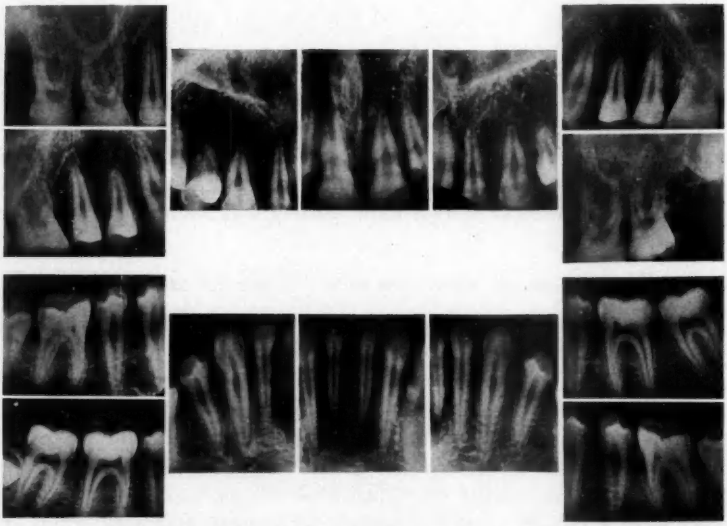

Fig. 6. Diabetes, 12 year duration. Male, age 15 years.

occlusions, found in diabetes even in patients less than 20 years old, has been pointed out as a possible factor in periodontal diseases of the diabetic patient.[22]

In reviewing the charts of 95 patients with long-standing diabetes in the age range of 16 to 78 years, 39 patients were found to have had clinical and roentgen evidence of marked or advanced periodontal disease; 24 patients had no evidence of periodontal disease; 31 patients had evidence of a slight to moderate degree of periodontal disease (one had no recorded finding on the degree of periodontal disorder); 50 patients showed evidence of marked oral neglect with poor personal oral care; 42 patients showed marked susceptibility to caries; 46 patients showed very slight to no dental caries; and 7 patients had no records of incidence of caries. One patient, aged 69 years, with marked

abrasion and poor oral hygiene, showed no evidence of periodontal disease and little evidence of susceptibility to caries.

In 174 patients listed with periodontal disease, 4 per cent were diabetic. The histories of two patients are of particular interest. A 49 year old woman with an uncontrolled, brittle type of diabetes had been under the care of a competent periodontist for about four years. Treatment had included gingival curettage. She had continued to have frequent, acute exacerbations of gingival symptoms with hypersensitivity of the teeth. The thought of losing her teeth was very disturbing to the patient. Her personal oral hygiene was excellent; she brushed her teeth twice daily. She smoked approximately twenty cigarettes daily. Dental caries activity was apparent; there had been considerable dental care of excellent character. Roentgenograms revealed an advanced generalized periodontal disturbance throughout both arches, in which the resorption of the supporting bone extended beyond the middle half of the roots and the involved root bifurcations.

The second patient, a housewife, had a history of an unhappy childhood in which neurotic tendencies were stated to be a factor. In September 1943, at age 29 years, the onset of diabetes mellitus was first recorded. The dental examination of the following year recorded slight susceptibility to caries, no peridontal disorder, and no dental pathology. Idiopathic convulsive disorder developed in 1947 as recorded by electroencephalography. A dental examination in 1950 because of the complaint of toothache and bleeding gums revealed early, localized periodontal disease and slight susceptibility to caries. In 1952, at the reported age of 35 years, she was found to be overly exhausted and not following her diet. In March 1954, urticaria developed. In June 1954, pregnancy was suspected, but was not determined. In July 1954, a dental examination revealed advanced periodontal disease, marked carious activity, and poor oral hygiene. At this time extensive dental surgery was carried out without complications, and prosthetic replacements of an upper denture and lower partial denture were inserted. In September 1955, cardiac changes were suspected. In November 1955, typical active Graves' disease with diabetic uncontrol was demonstrated. In December 1955, she was treated for neurotic dermatitis. In May 1957, when last seen, treatment was being directed for urticarial eruption.

These reports suggest factors other than primary endocrine disturbances in alterations of metabolic processes as a cause for the breakdown of the dental structures. These degenerative processes may be part of an over-all syndrome of exhaustion as described by Selye.[16] Although endocrine imbalances are involved, they may be the result of other factors.

CONCLUSION

Thyroid hypofunction, as one of the more common disorders of the endocrine system, would seem to have the most clearly direct result upon the dental structures. Childhood and adolescence are the most critical periods in which to study these effects.

To avoid mistakes in diagnosis, it is essential to seek physiologic and chemical evidences of specific hormonal dysfunctions rather than to draw deductions merely from structural abnormalities of growth, development[22] and dental abnormalities which may be related to endocrine disturbance. There is yet much to be clarified in the relationship of the endocrine function and dental pathology.

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Oral Roentgenographic Manifestations of Systemic Disease

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Many systemic conditions present characteristic manifestations. Dentists have long been aware of the soft-tissue changes associated with some general diseases such as diabetes, blood dyscrasias, and nutritional disturbances. They have recognized that certain conditions may give rise to altered formation of the teeth, with syphilis being especially prominent in this consideration. Some members of the specialty groups have studied their field with attention to bone growth, maintenance and preservation. Bone patterns evident in dental roentgenograms are becoming more meaningful to a greater number of dentists in their search for caries and dental infection and frequently provide roentgenographic information beyond, or in addition to, that sought.

Dentists are becoming increasingly aware that the roentgenographic patterns of the jaws are often characteristic or diagnostic of systemic disease, and that the effects of disease upon the teeth can be found only on roentgenographic examination.

This chapter has been prepared to provide information which will be useful to the practicing dentist. Important factors which control the technical excellence of the x-ray picture will be mentioned, and various systemic diseases will be grouped in such a way as to offer possible explanations of the deviations from "normal" which may be observed by the study of intraoral and extraoral roentgenograms.

When all technical factors involved in obtaining the exposure of the dental film have been controlled, the roentgenogram can be viewed with the assurance that any departure from the average or usual will have diagnostic significance or potentiality. It may seen unnecessary to stress such simple items as position of the patient in the dental

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chair, the chair itself, angulations of the tube, the exposure factors, milliamperage and voltage, the dark-room routine of controlled temperature, time and the simple matter of proper fixing after correct development, not to mention the importance of proper washing of the film. Without standardization of correct procedure in the exposing and processing of film, no base line or standard is established by which to evaluate what is seen in the finished roentgenogram. The continual pressure on the practicing dentist to take care of more and more patients makes it reasonable to think of the work that can be delegated to trained office personnel. Were a technician to have such responsibility, it would be mandatory that every processed film for every patient be handled in exactly the same manner. Were such not the case, there would be no uniformity of finished roentgenograms in a single full-mouth survey—and certainly not from patient to patient, or from day to day. Variations may be duplicated by the alteration of but a single factor with all other steps being held constant, and it is usually not possible to tell whether milliamperage, voltage, distance, exposure, or development time was altered. The limited roentgenologic examination of an occasional patient fails to offer data and experience that are essential if the dentist is to develop an awareness of the potential offered by intraoral roentgenography.

With the information made available through intraoral roentgenography the dentist may suspect or recognize disease by noting the accelerated or retarded formation and eruption of teeth and by observing the presence of teeth which have formed imperfectly or with structural defects.[13] Attention to the trabecular pattern of bone as well as to altered roentgenographic densities and the presence of lesions may make it possible for the practicing dentist to detect evidence of disease in patients before they have any complaints referable to the disease. The early referral of such patients for medical investigation may be extremely important in bringing about recognition at an early stage when treatment is most efficacious.[15] In this respect we are better able to serve the total patient instead of treating dental disease alone.

RETARDED DEVELOPMENT AND ERUPTION OF TEETH

Generally speaking, any condition or disease which causes a retardation or arrest of skeletal growth also may give rise to retained primary dentition and to slower than normal development and eruption of the permanent dentition.[14] The conditions in which delayed development and eruption of teeth occur and which are to be discussed are as follows: hypothyroidism, hypopituitarism, achondroplasia, cleidocranial dysostosis, and ectodermal dysplasia.

Hypothyroidism. Congenital or early hypothyroidism results in a skeletal dwarfing called "cretinism." The size of the teeth may not be influenced even though osseous dwarfing occurs. However, jaw relationships, and hence occlusion, may be altered because the bone at the base of the skull may be underdeveloped. In this endocrine disorder the dentist will notice not only the underdeveloped jaws but also retarded development and eruption of permanent teeth. The teeth are not reduced in size, so overcrowding is to be expected. The dental development will be found to vary with the chronologic age according

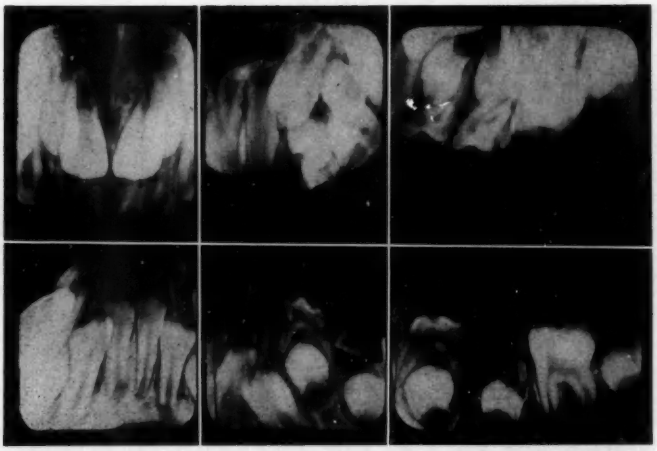

Fig. 1. Hypopituitarism in a 12 year old patient, showing the delayed exfoliation of primary teeth and retarded eruption and maturation of the permanent dentition. The dental age is retarded by 6 to 7 years, as compared to the chronological age.

to the time of onset and severity of the disease. Hypothyroidism occurring in an adult does not affect dental structure.

Hypopituitarism. The pituitary has been referred to as a master gland, but the interrelationship of all endocrine glands makes it difficult to isolate the influence of a single gland on the developing teeth and supporting structures. The hypofunction of this gland in early life results in an abnormally small, though well proportioned, person. The size of the teeth is not influenced, but their formation and development, as well as eruption and maturation, are retarded (Fig. 1). The jaw bone usually is roentgenographically normal, but the presence of retained primary teeth, with permanent teeth retarded in their development and eruption, is of importance to the dentist. The problem of dental treatment is one which deserves considerable

thought, for succedaneous teeth may not erupt any earlier than usual after removal of the retained primary teeth. Also, the abnormally shorter jaws may not accommodate all of the teeth when and if they do erupt.

Achondroplasia. In this disease the diagnosis usually has been established prior to the first visit of the patient to the dental office. Persons with this disease exhibit essentially normal body trunks, but abnormally shortened extremities, explained on the basis of disturbance of endochondral osteogenesis. These patients usually have retrusion of the maxilla, saddle nose and prominent frontal bosses because of delayed growth of the base of the skull.

The dental picture may show interference with development and eruption of the teeth, with noneruption being a prominent feature.[9] Whether the character of the bone is chiefly responsible for the fact that teeth form and remain entirely in the jaw is not known, for a similar dental picture is to be found in patients with cleidocranial dysostosis, except that in the latter disorder primary teeth often are retained.

Cleidocranial Dysostosis. In cleidocranial dysostosis primary teeth may be retained, eruption of the secondary dentition may be delayed, and many teeth may remain within the jaw bones. There is a marked tendency toward formation of supernumerary teeth and tooth structures. Follicular or eruptive cysts may be present. Late eruption is common, and the condition may exist in all quadrants. It frequently has been necessary for a dentist to provide such patients with partial dentures, removing individual teeth as they tend to present through the oral mucosa, whether because of eruptive movement or alveolar resorption. Many of these patients exhibit partial or total aplasia of the clavicle and delayed closure of the fontanels and sutures, as well as an underdevelopment of the facial bones, which makes the more or less normal mandible seem prognathic.

Ectodermal Dysplasia. This hereditary condition is marked by absence of perspiration and defects of the dermal structures such as hair, teeth and skin, with the dental feature being partial or total aplasia. The tissues arising from the ectodermal layer are affected, and dental structures may offer the only suggestion as to the time of onset.[7] In this respect the initiation of formation of teeth is the most important consideration. Initiation of the first tooth occurs about the seventeenth week of gestation. Knowledge of the schedule of development of the various teeth makes it possible to estimate the time of onset of the disorder. The important dental finding is the symmetrical absence of teeth and underdevelopment of alveolar bone in the regions where the teeth failed to form.[10]

ACCELERATED DEVELOPMENT AND ERUPTION OF TEETH

Systemic disorders which give rise to premature or abnormally early skeletal growth and maturation also may cause acceleration of the development and eruption of the teeth. To be discussed are hyperthyroidism, adrenogenital syndrome, and unilateral hyperplasia of the face.

Hyperthyroidism. When hyperthyroidism or hyperfunction of the thyroid gland occurs in children, skeletal growth and development and eruption of teeth are accelerated. Dental maturation will be completed at an earlier date. When studying tooth development, it is well to take into consideration not only the development of the tooth and its eruption into function but also the completion of the formation of

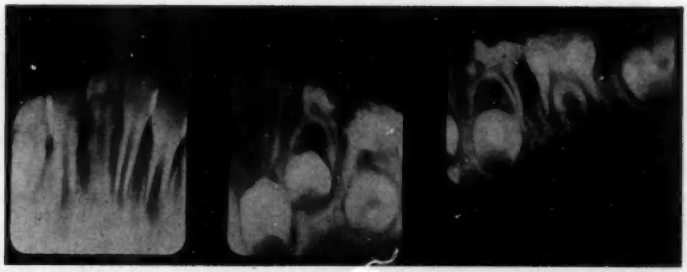

Fig. 2. Precocious skeletal and sexual development in a 4½ year old boy who had elevated 17-ketosteroids. The development and maturation of the teeth approximate those usually found at 7 to 8 years of age.

the apical portion of the tooth. Osteoporosis sometimes is observed, but is not necessarily important in the diagnosis of the disease, for it is not confined to instances of thyroid disease alone.

Adrenogenital Syndrome. Tumors or hyperplasia of the adrenal cortex results in precocious skeletal and sexual development. Hirsutism may be present. Accelerated growth and development are coupled with early maturation, so that final arrested growth may be an important feature. The dental development and eruption are proportionately accelerated (Fig. 2).

Unilateral Hyperplasia of the Face. This condition also is referred to as "facial giantism," for it is recognized by the unilateral enlargement of the facial structures on the involved side, including the ear, mastoid, zygoma, maxilla and mandible. Associated with it is also premature development as well as formation of larger-than-normal teeth in the dental arches on the enlarged side. The tongue may be enlarged and of such character as to suggest lymphatic involvement. One value of an early diagnosis is the possible prevention of unwar-

ranted irradiation and its sequelae. The dental arches on the involved side show unilateral and earlier dental development as well as overdevelopment, so that occlusion is disturbed, varying with the amount of involvement and the patient's age. The dentist may exhibit ingenuity in treating these patients. In some cases suitable prostheses may be provided which may improve, indeed they may provide, occlusion and improved phonetics. This is an admittedly rare disturbance, but it is remarkable enough that every practicing dentist should recognize the disease from roentgenographic evidence alone. While the diagnosis may be obvious from the clinical findings alone, the intraoral and extraoral roentgenograms will enable detection of the advanced development and eruption, and comparison with the "normal." The uninvolved side acts as the control.

STRUCTURAL DEFECTS OF THE TEETH

Among the diseases which give rise to structural defects of teeth are syphilis, rickets and hypoparathyroidism.

Syphilis. This condition, when it is congenital, may give rise to malformation of teeth. The typical picture to be seen both roentgenologically[11] and clinically[2] shows incisors and first molars, and occasionally cuspids, to be hypoplastic; also, the molar teeth have the "mulberry" occlusal pattern, and the incisors show evidence of notching, with the maxillary centrals showing a decreased mesiodistal dimension at the incisal edge. Often one can confirm the diagnosis of congenital syphilis by observing the association of Hutchinson's triad, that is, otitis media, interstitial keratitis and the typical teeth.

Rickets. Rickets may occur in infancy, in childhood, and in adulthood. Vitamin D deficiency is responsible for the condition, with lack of calcium and phosphorus also playing a part. Malnutrition or starvation affects the infants; in children a resistance to vitamin D known as "rickets tarda" may develop; adults may not be able to absorb vitamin D and utilize calcium in certain disturbances such as sprue, with a resulting deficiency of calcification of bone referred to as "osteomalacia." Enamel usually is not affected unless the disturbance is particularly severe, and then other factors may be responsible. There may be retarded formation of dentin, which is apparent in the large size of the pulp chambers and canals in rickets tarda. In addition to the retarded formation of dentin, diffuse inflammatory-like lesions may be present bilaterally and in either or both jaws in the marrow near the apices of the incisors, particularly the laterals. Fistulas have been seen in conjunction with these lesions, and biopsies have not proved helpful, for on entering these regions large voids are encountered.

Some of the teeth in the involved areas have been retained successfully by endodontic treatment. When massive doses of vitamin D have been employed as treatment of the resistant rickets, new dentin is observed to be formed, the pulp chamber and pulp canals are reduced to more normal size, and the newly formed dentin appears more radiopaque than the dentin formed prior to treatment, thus affording evidence of response to treatment.

Hypoparathyroidism. This condition, which results from reduction or absence of secretion of the parathyroid glands, may be present at birth or shortly after birth. It may follow the removal of the thyroid gland, owing to the coincidental removal of the parathyroid glands, or it may occur without any known cause. If present before or during

Fig. 3. Left mandibular teeth of boy 14 years of age, showing normally formed cuspid (canine) and first permanent molar. First clinical symptoms of disease occurred when he was about 1 year of age, after initiation and beginning development of canine and first molars. The second molar and premolars, which developed following early symptoms, show defects in the enamel.

the formation of teeth, the formation of dentin and enamel may be altered[8] (Fig. 3), especially in patients with symptoms of hypocalcemia such as convulsions, carpopedal spasms, and laryngeal stridor. The clinical characteristics are shortening of the roots of premolar teeth and hypoplasia of enamel. Lowered concentrations of calcium in the blood may be responsible for interference of tooth formation. Teeth formed after effective treatment may approach the normal.

DISORDERS WHICH MAY GIVE RISE TO ABNORMAL TRABECULAR PATTERN AND ROENTGENOGRAPHIC DENSITIES OF BONE

Bone is a tissue which normally is being formed, destroyed and reformed as a continual and ever-present process. The variations that occur and that are to be seen in the x-ray picture are alterations in the trabecular pattern and decreased or increased radiolucency and radiopacity. The following disorders are discussed to present these changes: protein deficiency, senility, postmenopausal state, osteogenesis imper-

fecta, osteomalacia, hyperparathyroidism, fibrous dysplasia of bone, Paget's disease, and osteopetrosis.

One of the greatest stimuli that bone receives is from stress and strain of function, or work. Nature is a great economist, and when bone is used it is maintained or strengthened in amount and density, and when it is not used there is a compensatory result to be observed in the x-ray picture as an increased radiolucency. The dentist may not see this response as vividly as the orthopedist, but he may see generalized skeletal changes reflected in the jaws, changes caused by deficiencies in matrix as well as deficiencies in calcification of the matrix.

Protein Deficiency. Although this condition is not presented as a particular disease entity, the dentist needs to understand that it may result from disturbances such as starvation, poorly controlled diabetes, Cushing's syndrome, hyperthyroidism, and nephrosis. The dentist may observe osteoporosis because the osteoblasts are not able to lay down the necessary organic matrix.

Senility. One of the greatest roentgenologic changes the dentist observes in older patients is atrophy, not only of the alveolar bone but also of the body of the mandible and the maxilla. When teeth are lost there is less functional stress, and trabecular rearrangement of alveolar bone results. The osteoporosis, or atrophy, is generally attributed to decreased steroids.

Postmenopausal State. The opportunity to observe postmenopausal osteoporosis is present in every dentist's practice and, because of its common occurrence, is the form of osteoporosis a dentist will observe most frequently. It is often more apparent that bone is of decreased density when teeth are present, for in the roentgenogram the tooth may serve as a standard for comparison of bone densities, and the contrast may be more obvious. It is not possible to tell from roentgenographic evidence alone whether osteoporosis might be caused by malnutrition, by the postmenopausal state, or from old age.

Osteogenesis Imperfecta. This is basically a disturbance of formation of the bone matrix, and failure of the osteoblasts to form organic matrix for normal calcification characterizes the disease. The bone trabeculae may be thin and coarse, and the cortices are thin, with resulting lack of structural strength. Multiple and repeated fractures may occur. If the condition is congenital there may be a dentinogenesis imperfecta, too. Blue sclera also may be a feature of the disorder. The teeth may show imperfectly formed dentin and reduction in size, or absence, of the pulp chambers. The opalescent dentin gives a brownish or amber hue to the teeth. Development of the tooth may present an odd picture; the root form may appear far in advance of the formation

and filling in of dentin, with the formation of dentin finally obliterating the pulpal chambers and canals.

Osteomalacia. In this disturbance the defect is in the calcification of bone matrix. Roentgenologic evidence may be lacking, or there may be an appearance of uniform and generalized radiolucency. The trabecular structure may be lacking, with abnormal thinning of bone cortex. The condition may be brought about by deficient absorption of calcium from the gastrointestinal tract, or by the excessive excretion

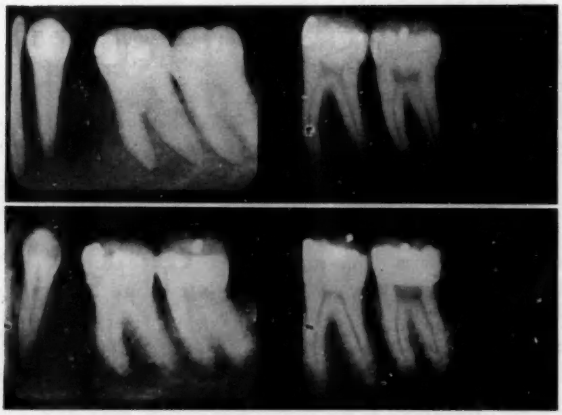

Fig. 4. Hyperparathyroidism. The upper roentgenograms show evidence of osteoporosis and loss of lamina dura and normal anatomic features usually seen in this region. The lower roentgenograms were made about 3 years later after successful treatment. The lamina dura has reappeared, and the normal contour, characteristic root forms and roentgenographic evidences of bone anatomy are again present.

of calcium from the body, usually through the kidneys, which leads to calcium deficiency.

Disturbances of assimilation of fat and steatorrhea (sprue or celiac disease) result in decreased absorption of the fat-soluble vitamins and calcium and in osteomalacia. Renal disease with acidosis also may result in osteomalacia.

Hyperparathyroidism. Primary hyperparathyroidism is due to an increased secretion of the parathyroid glands, which causes increased withdrawal of calcium from the bones and results in increased concentrations of calcium in the serum. The condition also can occur without evidence of any bone disease. Nevertheless, the dental roentgenogram often may prove to be an important diagnostic aid.[5] The presence or absence of the lamina dura, or tooth-socket cortex, is an

important feature (Fig. 4). There are other changes which the dentist also should consider. If there is generalized decalcification, anatomic detail usually seen in the x-ray picture will be modified or lacking. Teeth are not capable of being physiologically decalcified because of the lack of circulation through the hard substances, so they serve as standards for comparison of roentgenographic bone density. The totally edentulous mouth also may show significant changes in this condition. The decalcification of the jaws will cause loss of bone contrast and of anatomic detail, and tumors or cystlike lesions may be evident roentgenographically. Fibrous localizations (osteoclastomas) may occur in the jaws, and may become expansive, causing bulging of the bone. Were a dentist to remove such a lesion surgically, he should submit it to a pathologist for study. The diagnosis of such tissue as giant cell tumor should certainly prompt the dentist to consider parathyroid disease as a cause.

After successful treatment by parathyroidectomy, bulging tumors may or may not regress slightly. Localized fibrous lesions which were evident roentgenographically will not change in trabecular pattern, but will become more radiopaque than the surrounding bone. Multiple lesions of this character may occur in both the maxilla and the mandible of a single patient.

Fibrous Dysplasia. In this condition there is a replacement of the medullary portion of bone by fibrous tissue. Thinning occurs from the inner side of the cortex, and the expansion, which then may follow, may lead to disfigurement. Because of the lack of symptoms when this condition occurs in the jaws, the apparent swelling or asymmetry, if occurring unilaterally, may be the first indication of the condition. Routine intraoral roentgenographic surveys may disclose the presence of fibrous lesions in the jaws. The fibrous lesion may be present in a single bone, or in more than one bone. The zones of involvement are usually well defined radiolucent regions with suggestions of trabeculae or regions of osteosclerosis occurring in the substance of the fibrous lesion. Surrounding bone is normal in character and appearance. If the lesion occurs in the maxilla, and roentgenograms show it to be superimposed over the maxillary sinus, it will appear more radiopaque than usual because of the radiolucency of the normal sinus and replacement of the sinus cavity by the lesion. Treatment is usually limited to correction of the deformity.

Paget's Disease (Osteitis Deformans). This disease of the skeleton may involve one or more bones. It tends to occur in the older age group, and is found frequently in the maxilla, less often in the mandible, and occasionally in both jaws. In this condition there seems to be an increase in the rate of destruction and repair.[8] The initial lesion

may be a bone fibrosis and, because of the increased radiolucency, the dentist may think of local infection in the jaw. But without dental symptoms, and with normal color and response to the vitality test, it is easy to rule out pathologic conditions of the teeth. As the disease progresses, sclerotic regions will be noted with coarse bony trabeculae occurring in the radiolucent regions as a result of formation of new bone. The bony trabeculae seem to present a cotton-wool appearance, and rounded margins of the various borders; in later stages, hypercementosis of the roots of the teeth in the region of involvement is characteristic. Overgrowth of bone may continue to the point that the maxilla may be reduced surgically to improve appearance and, in some instances, to enable a denture to be made and worn.

Osteopetrosis. Osteopetrosis also is known as Albers-Schönberg disease, marble bones, and chalky bones. The thickness of the cortex becomes greatly increased, and osteosclerosis may obliterate the dental roots on the x-ray picture. The difficulty seems to arise from an inability of bone to be reabsorbed. It is a hereditary disease in which osteosclerosis is a prominent factor, with cortical bone replacing bone marrow. Anemia may result from the reduction or absence of bone marrow. The replacement of marrow carries with it a reduced blood supply so that infection is always a problem to be considered; occasionally it is encountered, especially after removal of teeth. The bones are weak, and fractures result from this fragility. The dental roots may be shorter than normal.

LESIONS IN BONE

No other place in the body is bone subjected to so many possibilities of stimulation as in the jaws. With the development and eruption of 20 primary teeth and 32 permanent teeth, the exfoliation of the primary teeth, the possibilities of infection which may follow caries or trauma—not to overlook trauma of the jaws—we probably should ask why more pathologic conditions are not encountered. In addition to pathologic lesions which can develop from dental origin, there are also those which may arise from bone itself. Lesions of the jaws which may be detected roentgenographically, and which cannot be diagnosed on the basis of roentgenographic appearance, should raise the question of generalized skeletal disease. Some of the conditions that should be considered are multiple myeloma and reticuloendothelial diseases.

The giant-cell tumors previously discussed, or brown tumors (brown nodes) which are sometimes found in the jaws in patients with hyperparathyroid disease, are similar to those solitary benign giant-cell lesions found in patients who have no generalized disease. The color

is attributed to hemorrhage or hemosiderin. When these tumors develop in bone there is compensatory formation of new bone around the destructive region, with noticeable swelling. This reaction is probably a strengthening reaction rather than an attempt to wall off the tumor. The usually well defined lesions are made up of fibrous-type tissue, but roentgenographically they may appear as cysts because of the radiolucency and definite borders.

Multiple Myeloma. This is a condition which is of hematopoietic origin, and the lesions are composed of plasma cells (plasmocytoma). A single lesion (solitary) may occur, but the most frequent occurrence is in the multiple or more general form, with more than one bone involved. Rarely do the lesions develop before the fifth decade of life, and Dahlin's study showed that more than 70 per cent of the patients were men. Bruce and Royer studied films of jaws in 59 cases of multiple myeloma; in 17 cases dental roentgenograms showed evidence of myeloma. This evidence of myeloma in the jaws points out the importance of oral roentgenography and the contribution that oral examinations can provide in the diagnosis of generalized disease. In the jaws the lesions tend to occur at the sites of the greatest amount of marrow. Later roentgenograms may show evidence of coalescence of previously isolated radiolucent regions. When the lesion is extensive and involves regions in which teeth are located, mobility of the teeth may develop.

Reticuloendotheliosis. This disturbance of the reticuloendothelial system is found oftenest in young children[6] and may be detected first by the dentist because of the oral symptoms which may be present. On clinical examination of the mouth, certain teeth may appear rather opaque, may prove to be mobile, and may be surrounded by necrotic tissue which has retracted apically. The x-ray picture is rather characteristic, and difficulty may be encountered in obtaining intraoral roentgenograms because of the lack of cooperation, or the inability to cooperate, on the part of some youngsters. Sedation and extraoral views may help. Roentgenograms of the head may permit adequate views of the jaws, but they are grossly lacking in detail of bone of the jaws and of regions about the teeth. The presence of granulomatous tissue about teeth gives rise to the appearance of teeth floating in the bone, devoid of any bone support. Some lesions occurring around the teeth will appear as lateral or periodontal lesions, at certain stages of the disease. If teeth are removed, the opportunity should be used to obtain tissue for the pathologist. If a developing tooth is removed the dental papilla may not prove adequate for study, so tissue from the region adjacent to the tooth should be obtained. Roentgenographically, the lesions which occur in the jaws may appear as single lytic lesions

(some with cortical boundaries) or they may be so extensive as to involve the body, ascending ramus, coronoid process and condyle. Rather early response to x-ray therapy may be detected and, when the lesions have been in the jaws, healing may be observed by use of intraoral or extraoral roentgenograms made at intervals of every few months.

Eosinophilic granuloma of bone is classified with histiocytosis,[12] and the destructive lesion of bone is a granuloma. The lesions in the jaws tend to be somewhat localized, and occur in the medullary portion of the bone or in the alveolar bone. Roentgenographically they

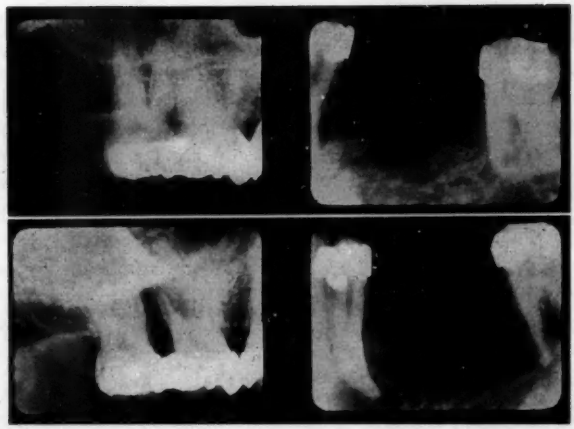

Fig. 5. Eosinophilic granuloma of bone in a 32 year old man. The lower pictures, made 7 months after the upper pictures, show evidence of continued involvement of the mandibular lesion and the rapid development of a new lesion of the maxillary bone between the molar teeth.

appear to involve the root of one tooth or the roots of many teeth. The lesions can occur in either or both jaws, and tend to be rather well delineated. Teeth may be mobile and undergo sloughing (Fig. 5). This may occur so rapidly as to make it necessary to rule out a malignant lesion.

In Figure 5, the top picture shows a lesion in the right mandibular edentulous space. The patient's teeth had become loose and painful 1½ years previously. After removal of the teeth, the patient experienced continual "discharge and foul taste" from the region. The lower pictures (Fig. 5), made 7 months later, show continued and progressive involvement of the bone in the edentulous mandibular region, as well as a new lesion in the left maxillary molar region.

COMMENT

Several systemic diseases which have similar influences on the dental system have been grouped together to remind the practicing dentist that factors which influence the rate of body development and maturation also may affect the dental field. Retarded development and eruption are encountered in patients with hypothyroidism, hypopituitarism, cleidocranial dysostosis, achondroplasia, and ectodermal defects. Accelerated development and eruption may be encountered in hyperthyroidism, in precocious puberty, and in unilateral hyperplasia of the face. Defects in structures of the teeth are to be found in association with diseases such as syphilis, rickets, and hypoparathyroidism.

The occurrence of abnormal trabeculae and altered roentgenographic densities offers a challenge to the dentist. The value of x-ray pictures is related directly to the technical control of the conditions under which the exposures are made, and the preparation for viewing. Increased radiolucency occurs in conditions of disuse and hormonal deficiencies, in osteogenesis imperfecta, in disturbances of protein metabolism, and in rickets. Bone pattern and densities are altered in hyperparathyroidism, fibrous dysplasia, multiple myeloma, and histiocytosis X. This article will have served the reader well if it prompts further study and a clinical awareness of the conditions which may be encountered in the general practice of dentistry.

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Oral Manifestations of Nutritional Disorders

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For generations, dentists and physicians have regarded the structures lining the oral cavity as a mirror which reflects the health of the entire body. The mouth tissues are affected early in the course of nutritional deficiencies, and objective and subjective alterations in these structures are often the chief complaint of patients seeking relief from nutritional disorders. All scientifically trained observers who have been associated with the Nutrition Clinic of the Hillman Hospital, Birmingham, Alabama at some time during its 22 year history have been impressed with the high incidence of oral lesions in newly admitted patients. In a representative series of 914 consecutive admissions, soreness of the mouth and tongue was the presenting symptom in 329 cases.[9] Clinical impressions gained from the prompt recognition of nutritional deficiency manifestations in the readily accessible oral structures greatly facilitated precise diagnosis and treatment.

As long as the oral tissues are properly nourished they withstand to a striking degree the repeated trauma to which they are subjected. In contrast, the same tissues when nutritionally depleted have great difficulty in maintaining their cellular integrity. Exposure to chemical, physical, thermal or microbial irritants accelerates the development of

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lesions affecting the color, topography and sensitivity of the involved structures. These lesions are almost invariably complicated by superimposed infections which alter the appearance and course of the underlying nutritional dyscrasia. The oral tissues differ in their vulnerability to identical nutritive restrictions in the same patient and in different patients. Patients observed through many recurrences of the same nutritional deficiency disease develop lesions in the same regular order and in the same definite site in a predictable pattern. Although the clinical manifestations may be multiple or single in causation and non-specific in appearance, certain oral structures have a greater predilection for change in the presence of protracted nutritional imbalance than do others.

For ease of presentation, the pathologic alterations induced by the nutritional deficiency states in the lips, tongue, gingivae, buccal mucosa, palatal mucosa and teeth will be discussed separately. Though these structures may at times appear to be preferentially involved, they are usually affected in varying degrees simultaneously.

ALTERATIONS IN THE LIPS

Degeneration and inflammation of the labial mucosa, variously termed angular stomatitis, cheilosis or cheilitis, is a prominent sign of riboflavin deficiency. Such lesions were observed frequently in association with pellagra and responded to treatment with dried brewers yeast powder or crude liver extract. Not until 1938, when Sebrell and Butler[8] successfully induced riboflavin deficiency in human volunteers, was the full significance of angular cheilosis appreciated. Within two months, Vilter, Vilter and Spies[12] reported that naturally occurring cheilosis resulting from a lack of dietary riboflavin was relieved by the administration of this vitamin.

The pathologic changes in the experimental and clinical types of riboflavin deficiency cheilosis are clinically identical. They follow a definite pattern of development beginning with a pallor of the lips, particularly at the angles, which spares temporarily the moist areas of the adjoining buccal mucosa. The pallor continues for several days and is followed by maceration and heaping of a whitish slough on a pink background. Superficial fissures then invade the natural folds at the corners of the mouth. The fissures are single or multiple and usually appear on both sides. Subsequently, the macerated lesions may dry and a yellowish crust forms at the angles which may be removed without bleeding. The remainder of the lips becomes abnormally red along the line of closure and there is a notable increase in vertical fissuring resulting from a superficial denudation of the mucosa. This is usually more apparent on the lower lip. As the

disease progresses, the lesions at the angles deepen and extend across the vermilion border onto the cheek for a distance up to 10 mm., and into the buccal mucosa for from 1 to 3 mm. The constantly irritated angles become raw with bleeding areas, crusts and scales. In some cases the angles of the mouth are very painful in the acute stage and may remain so throughout the course of the disease. Usually the lesions are well tolerated by the patient. When they recur repeatedly and are deep enough, scars develop which give the affected area an atrophic appearance. Secondary infection with hemolytic streptococci, hemolytic staphylococci, yeast, fungi and herpes virus are common during the acute stage.[7] These agents may alter the morphology of the lesions. A typical case of cheilosis associated with riboflavin deficiency is shown in Figure 1. Administration of riboflavin in oral doses of 20 mg. per day produced rapid and complete healing along with a disappearance of the characteristic microbial overgrowth.

Angular cheilosis is not an exclusive manifestation of riboflavin deficiency and should not be considered pathognomonic of this disease. In some cases of iron deficiency anemia with cheilosis that is clinically indistinguishable from the type shown in Figure 1, healing occurs when the anemia is corrected. On occasion, disappearance of the lip lesions has been observed to follow the administration of such dissimilar substances as niacin, pyridoxine, pantothenic acid, ascorbic acid, folic acid or vitamin B_{12} in cases in which a specific deficiency of one of these nutrients was the precipitating cause. Other factors not directly nutritional in character which must be considered in the clinical differentiation of angular cheilosis are sensitivity to foods, denture materials, cosmetics and actinic radiation; antibiotic therapy which produces alterations in the prevailing oral microbial flora; irritation caused by habitual licking of the angles of the mouth (perlèche); and loss of vertical dimension in the lower third of the face. The latter is common in edentulous patients without prosthetic replacements and in those with poor fitting dentures which fail to restore the canine eminences and proper tooth height. The term "pseudocheilosis" has been applied to such cases and it has been proposed that these lesions can be distinguished from nutritional deficiency cheilosis by their characteristic downward and outward radiation from the angles of the mouth. In many patients, however, the mechanical and dietary factors are present and operative concurrently, rendering such arbitrary distinctions of doubtful clinical value.[4]

ALTERATIONS IN THE TONGUE

A vast and formidable range of change involving size, color, structure and sensation of the tongue occurs in many nutritional deficiency

states. The lesions begin in one or more localized areas. As the disease progresses, more and more sites become involved until the entire tongue may be affected. In many patients the lesions remain localized and well demarcated for long periods of time without undergoing any progression. Changes in color range from extreme pallor to intense redness to purplish blue to magenta. They are not, in themselves, indicative of the specific underlying nutritional deficiency. Thus, a fiery red or scarlet tongue may characterize acute pellagra, pernicious anemia and the macrocytic anemias of sprue, pregnancy or infancy; a pallid tongue is often associated with an anemia characterized by a low hemoglobin content due to a deficiency of iron, folic acid, vitamin B_{12} or even ascorbic acid; a magenta tongue occurs in riboflavin deficiency and healing pellagra; a "beefy red" tongue may denote chronic deficiencies of several of the B group of vitamins.[10]

It may be extremely difficult to differentiate clinically between the color changes in the tongue which accompany the deficiency states and those resulting from local or systemic disturbances that are not primarily nutritional in origin. Thus, the tongue is deep red immediately anterior to the circumvallate papillae in patients with median rhomboid glossitis, a developmental anomaly in which the lateral halves of the tongue fail to fuse prior to the interposition of the tuberculum impar. In lingua geographica, a benign glossitis of unknown etiology, the depapillated areas on the dorsum are bright red in color. Similarly in Moeller's glossitis, a rare, chronic cyclic condition of unknown causation seen mainly in women, the tongue is characterized by excruciatingly painful, circumscribed, raw, bright red patches. The glossitis of nutritional deficiencies is often mimicked in allergic diseases.

Like the color changes, topographic alterations in the dorsum of the tongue are variable in origin and progressive in appearance. Involvement of the fungiform papillae precedes that of the filiform papillae. The usual order of change is hypertrophy, flattening, fusion and atrophy. The rate at which these changes occur varies with the patient and with the severity of the deficiency state. While atrophy of the lingual papillae is an early and prominent sign in acute pellagrous glossitis and in the megaloblastic anemias responsive to folic acid and vitamin B_{12}, hypertrophy of the papillae prevails in riboflavin deficiency. A granular or pebbly tongue with flattened mushroom-shaped papillae characterizes this condition. In early sprue, a strawberry appearance of the tongue may be produced by the general reddening of some papillae and atrophy of others. The changes recede and recrudesce, leading eventually to the total papillary atrophy of the tongue in the advanced condition. In beriberi, the fungiform papillae may become enlarged, edematous and hyperemic.

Non-nutritional conditions may produce changes in the lingual papillae which are indistinguishable from the dietary deficiency syndromes. Hypertrophic lingual papillae are found typically in papillitis and in lingua nigra, or black tongue. Papillitis characterized by painful, hyperemic, hypertrophic circumvallate papillae is seen occasionally in elderly patients in the absence of other lingual pathosis. The lesions are usually confined to the lateral aspects of the tongue and are produced by irritation from sharp tooth margins or ill fitting dentures. Removal of the irritant is the treatment of choice in such cases. Black tongue in dogs is analogous to pellagra in man and is amenable to treatment with niacin or niacin amide. Human black tongue results from an infection of the dorsum by pigment-producing microorganisms. The filiform papillae become hyperkeratinized and hyperplastic. The widespread use of broad spectrum antibiotics has been followed by a noticeable increase in the incidence of human black tongue. Such cases are attributable to a disturbance in the normal balance of the oral flora with a consequent overgrowth of pigment-producing oral fungi. Atrophy of the lingual papillae which resembles clinically that of the nutritional deficiency states is common in patients with gastric hypoacidity and chronic alcoholism, in each of which there may be a strong nutritional overlay.

Burning, swelling with tooth indentations along the margins, and ulceration of the tongue are fairly constant findings in the acute stages of pellagra, sprue, pernicious anemia and nutritional macrocytic anemia. At the onset of pellagrous glossitis only the tip and lateral margins of the tongue are swollen and reddened. With time the swelling increases and the red discoloration becomes more intense. Deeply penetrating ulcers appear along the sides and tip, rarely on the dorsum. In the early stages of sprue, the dorsum of the tongue is inflamed and contains crops of minute whitish painful ulcerations with fiery red borders. Superficial whitish ulcers resembling aphthous ulcers develop on the dorsum of the tongue in pernicious anemia and nutritional macrocytic anemia. Soreness of the tongue occurs at some time in at least 50 per cent of cases of pernicious anemia. Glossitis in this disease may be the initial symptom and may appear when there is little or no anemia. When glossitis is at its peak, the tongue is very sore, painful and "beefy red" in color. It may involve the entire dorsum or be confined to patches at the margins or dorsal surface. In some instances inflamed vesicles develop, rather than shallow white ulcers. The entire mouth and throat may pain and burn on swallowing. Usually the burning or soreness is confined to the anterior half of the tongue. The intensity of the glossitis subsides after several days, only to recur at intervals of varying length. Between attacks, the epithelium of the tongue becomes devoid of papillae, resulting

Fig. 1

Fig. 4

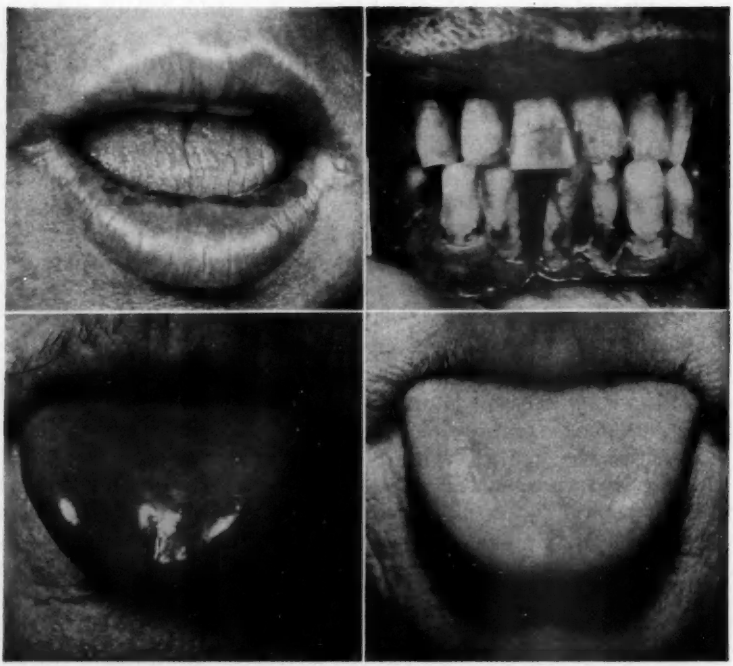

Fig. 2

Fig. 3

Fig. 1. Bilateral cheilosis due to lack of riboflavin. Lesions disappeared following therapy.

Fig. 2. Slick, denuded tongue of a patient with pernicious anemia in relapse, showing striking atrophy of the lingual papillae and discoloration of the tongue.

Fig. 3. Same patient as in Figure 2, after two weeks' treatment with vitamin B_{12}, now shows regrowth of lingual papillae and disappearance of the abnormal color of the tongue.

Fig. 4. Advanced destruction of periodontal tissues and chronic Vincent's infection in patient with endemic pellagra.

eventually in a smooth glazed tongue as shown in Figure 2. Administration of vitamin B_{12} to this patient resulted in a prompt regrowth of the lingual papillae (Figure 3). This case exemplifies the striking changes which follow the use of specific therapy in the nutritional deficiency states.

Soreness and burning of the tongue may also occur in pellagra and in iron deficiency anemia before any other changes become visible. In iron deficiency anemia a sore tongue or sore mouth occurs in approximately 30 per cent of the cases. The pain rarely approaches the intensity of that found in pernicious anemia. It may, however, extend to the pharynx, resulting in spasm and dysphagia which characterize the so-called Plummer-Vinson syndrome. In riboflavin deficiency the tongue may be painful and burn when food is introduced into the oral cavity, but because of the lack of desquamation, the soreness of the tongue is usually not as severe as in the aforementioned deficiency states. Loss or diminution of the sense of taste is seen occasionally in beriberi and rather frequently in pellagra and pernicious anemia. The differentiation of the etiology of glossodynia must include galvanism, localized arteriosclerosis, gastrointestinal disorders, allergies, cancerophobia, neuritis of the lingual nerve and malposition of the teeth in the dental arch. The presence of tongue ulcers necessitates the consideration of tuberculosis, herpes, aphthous lesions, allergies and the nutritional and blood dyscrasias as the possible precipitating cause.

ALTERATIONS IN THE GINGIVAE

The unique anatomic relations of the gingivae render these structures exquisitely sensitive to deficiencies of the nutrients essential for their maintenance and repair. Subjected to recurrent trauma from two opposing directions simultaneously, slight defects in the integrity of the gingivae may be readily magnified into clinical manifestations. Gingival involvement is frequently the first sign of scurvy and, while rarely the initial pathologic alteration in pellagra, the incidence of gingivitis and periodontal destruction in this disease is extremely high.[2]

The gingival changes in scurvy do not ordinarily develop in the absence of teeth. In infants and young children, the mucosa directly over the erupting teeth becomes engorged, spongy and bluish in color. After eruption the teeth are partially or completely covered by hypertrophied gingival tissue. In adults, with a partial dentition, the scorbutic changes are confined to the gingivae immediately surrounding the teeth, the edentulous areas remaining undisturbed. In adult scurvy the gingivae are swollen, slick, congested, boggy and tender. The color ranges from bright red to bluish purple to black.

The gingivae bleed easily during mastication and upon the application of slight direct pressure. The scorbutic manifestations proceed in a definite order, affecting the interdental papillae, marginal gingivae and alveolar gingivae in sequence. The maxillary and mandibular gingivae are not always equally involved; often, but not invariably, the upper gingivae show the more advanced process. With time the teeth become mobile owing to an imbalance between the respective rates of degeneration and regeneration of the collagenous fibers comprising the periodontal membrane. If untreated, the teeth may exfoliate because of the total destruction of the periodontium and osteoporotic changes in the supporting alveolar bone. Superimposed upon the gingival hemorrhages and hyperemia are epithelial degeneration and ulceration compounded by secondary microbial invasion. Scorbutic gingivitis responds promptly to the oral administration of 500 mg. ascorbic acid per day. In some instances, vitamin P (rutin or hesperidin), the so-called capillary permeability factor, may have to be given along with vitamin C to obtain a complete remission.

In acute niacin deficiency the protective powers of the gingival epithelium are diminished. Invasion by fusiform bacilli, *Borrelia vincenti* and proteolytic streptococci and staphylococci is extremely common. Vincent's infection has been observed in almost every case of acute pellagrous stomatitis seen in the Nutrition Clinic.[1] The typical lesions appear as wedge-shaped, punched-out ulcers affecting the interdental papillae and marginal gingivae. The lesions are necrotic, tender, foul-smelling and hemorrhagic. They are covered with a grayish white pseudomembrane superimposed upon a fiery red base. The infection spreads to involve the tongue, buccal, labial and palatal mucosa. The extensive degree of destruction of the gingivae and supporting dental structures which occurs in chronic pellagra is shown in Figure 4. Niacin amide in doses of 100 mg. per day orally or 25 mg. per day intravenously is effective in clearing the Vincent's infection secondary to pellagrous stomatitis. It must be emphasized that a niacin deficiency is not a contributing factor in all cases of Vincent's infection. When it is, correction of the deficiency leads to a rapid subsidence of the infection.

Degenerative changes in the gingivae have been produced in monkeys and dogs fed diets deficient in either folic acid or pyridoxine. In man the signs of the folic acid deficiency syndromes often include inflamed hypersensitive gingivae and aphthous stomatitis in addition to glossitis and macrocytic anemia. Fiery red, excruciatingly painful mucous membrane lesions involving the gingivae, tongue and pharyngeal and buccal mucosa have been reported in patients with pernicious anemia which has progressed to subacute combined degeneration of

the spinal cord.[11] These lesions responded readily to the administration of liver extract or vitamin B_{12}. In contrast to the reddening of the gingivae which occurs in the anemias attributable to deficiencies of some of the B vitamins, the gingival mucosa in iron deficiency anemia frequently appears pale and wan.

Vitamin K deficiency resulting from hepatic, biliary tract or intestinal disease or from prolonged Dicumarol therapy may induce gingival bleeding. In severe cases of vitamin K deficiency, a slow oozing of blood from the gingivae similar to that noted in diseases which disturb the blood clotting mechanism has been encountered.

ALTERATIONS IN THE BUCCAL AND PALATAL MUCOSA

Nutritional derangements which cause disturbances in the buccal and palatal mucosa include deficiencies of the B group of vitamins, vitamin C, iron and allergies to ingested foodstuffs. The buccal lesions may be either primary or secondary in the form of extensions from those arising in the lips or gingivae. In riboflavin deficiency, angular cheilosis, if untreated, will proceed for a short distance into the adjoining buccal mucosa. In pellagra, the prodromal symptoms include a drying and burning sensation in the oral mucous membranes, while in the acute stage the buccal mucosa and that covering the soft palate and pharynx becomes denuded, swollen, reddened and tender. If untreated, the process extends to involve large areas which become ulcerated and subject to infection. In scurvy, the discoloration, swelling and congestion of the gingivae may proceed into the mucobuccal folds and onto the buccal mucosa. Painful, diffusely reddened mucous membrane lesions with or without ulceration are frequently found in patients with the anemias and sprue syndromes, and are relieved by either folic acid or vitamin B_{12}. In many cases of sprue, small aphthous ulcers develop in the buccal mucosa. The oral mucous membrane changes in deficiencies of the B group of vitamins and nutritional anemias are a common cause of loosening of previously well adapted dentures in edentulous patients. Pallor of the oral mucosa, with small vesicles surrounded by areas of erythema, occurs in many cases of hypochromic iron deficiency anemia. The labial, buccal and palatal areas are frequent sites for the oral manifestations of allergic reactions to ingested foods. Such lesions are usually vesicular in nature, extremely tender and surrounded by a localized edema and erythema.

Vitamin A functions to maintain the integrity of specialized epithelial tissue. When deficient in vitamin A, the basal cells proliferate to produce a keratinized epithelium which is extremely susceptible

to bacterial invasion. In the late stages of human vitamin A deficiency, hyperplasia and hyperkeratosis of the gingivae, leukoplakia and severe infections of the oral mucous membranes may develop.

ALTERATIONS IN THE TEETH

Clinically manifest rickets due to vitamin D deficiency is essentially a disease of rapidly growing children. Premature infants are especially prone to rickets because of their rapid growth rate and relatively poorly mineralized skeletons. In rachitic children, eruption of the deciduous teeth is delayed and the order of eruption is altered. Defects in the enamel of deciduous teeth are extremely rare in contrast to the gamut of hypoplastic changes ranging from pitting and grooving to absence of the enamel which may occur in permanent teeth formed during a period of prolonged uncorrected rickets. The defects are found in the permanent incisors, cuspids and first molars, since their periods of development coincide with the ages at which rickets is most common. In osteomalacia, an adult form of vitamin D deficiency, the most prominent change involving the oral structures is a loss of the lamina dura from about the teeth.

Dental changes in human scurvy affect primarily the pulp and dentin. Changes in the pulp consist of hyperemia, edema, necrosis and calcification; in the dentin, they include degeneration of odontoblasts, porosity and the formation of irregularly canalized secondary dentin. The changes are most prominent in the apical third of the teeth and are often seen before the other bony alterations become manifest.

Many clinicians continue to look upon dental caries as a sign of undernutrition in complete disregard of the progress made in recent years in elucidating the role of nutritional disorders in the pathogenesis of this disease. To evaluate properly the influence of diet on dental decay it is necessary to distinguish between undernutrition, malnutrition and overnutrition. These nutritional states must be assessed in terms of the areas of general agreement concerning the etiology and pathology of dental caries.

Dental caries is a posteruptive microbial disease of tooth structure. It develops initially in the pits and fissures, at the gingival third of the buccal and labial surfaces and immediately below the contact points of the teeth. Irrespective of anatomic location, the caries process begins at the external surface and extends progressively into the enamel and dentin. These structures are comprised mainly of complex salts of calcium which are insoluble in saliva but soluble in relatively weak acids. Dental enamel, the first portion of the tooth to be attacked by the caries process, is avascular and acellular and thereby

completely devoid of powers of regeneration. Caries of the enamel is thus characterized by an irretrievable loss of tooth structure.

Investigations with human beings do not correlate with the impressions gained from animal experimentation that deficiencies of vitamins A, C, D and K during the formative period of the tooth are common causes of defective calcification. Deficiencies of calcium, phosphorus and protein during the developmental period are not likely to produce disturbances in enamel, although they may affect dentin and bone. Regardless of cause, however, defective calcification per se does not predispose to tooth decay. The teeth of persons with mottled enamel in areas of endemic dental fluorosis are notoriously immune to decay although they are grossly hypoplastic. Except for fluorine, deficiencies of the presently known dietary elements during the period of tooth formation are not conducive to subsequent susceptibility to dental caries.

The eruption of the tooth into the oral cavity exposes the clinical crown to possible destruction. Human saliva contains an abundant bacterial flora, many species of which are capable of producing acids in amounts sufficient to decalcify tooth structure. Such action is dependent upon the presence of a suitable substrate, notably ingested fermentable carbohydrates retained in the so-called sheltered areas of the teeth. Clinical studies show that dental caries activity in susceptible persons exists in direct proportion to the quantity of fermentable carbohydrates contained in the diet. Attempts to prevent dental caries by nutritional means other than by stringent restriction of the carbohydrate content of the dietary have met with questionable success. Dietary supplements of vitamin C, vitamin D, calcium and phosphorus have each been tested for their protective action against tooth decay and found wanting.

In sharp contrast is the repeated observation that persons on starvation or near starvation diets have a very low incidence of dental caries when compared with adequately nourished groups of the same ethnic background and geographic area.[5] The relatively low incidence of dental caries in patients with chronic nutritional deficiency diseases is accompanied by an extremely high prevalence of advanced periodontal disease in such patients. In 1945, Mann, Mann and Spies[6] studied 160 edentulous patients with long-standing multiple deficiency diseases and found that periodontal involvement was the chief cause of extraction in 131 (82 per cent) of the cases. Subsequently, Greene, Dreizen, and Spies[3] examined 466 consecutive patients at the Nutrition Clinic and noted that 350 (75 per cent) were either edentulous or had fewer than three occluding anterior and posterior teeth. Of the 268 edentulous patients in this series, the greatest number had their

last extraction between 46 and 50 years of age. Thus, while protracted undernutrition may preserve tooth structure, deterioration of the supporting dental tissues results in early tooth loss.

SUMMARY AND CONCLUSIONS

The pathologic alterations which occur in the various mouth structures during the nutritional deficiency states have been discussed in some detail. The oral manifestations of the dietary disorders frequently precede the other clinical signs and symptoms of these diseases. Since the oral changes may be non-specific, a definitive diagnosis can only be made on the basis of a complete physical examination, a thorough dietary and medical history and appropriate laboratory and roentgenographic studies. Once such a diagnosis is made, prompt, adequate and persistent therapy is indicated since procrastination may lead to irreversible tissue damage and death.

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Physiologic Effects of Fluoride as Related to Water Fluoridation

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Probably no public health measure has been more thoroughly evaluated prior to its use by the public than the fluoridation of drinking water. A fluoridated communal water supply containing 1.0 ppm of fluoride has proven to be remarkably effective for the partial control of dental caries. Fluoridated water is likewise free of harmful physiologic effects on those who use the water. The discovery of this highly beneficial relation of fluoride in drinking water to dental caries and its rapid adaptation to public use is without doubt the most significant development in the history of preventive dentistry.

Acceptance of fluoridated water by a community as a whole frequently has been accompanied by a great deal of controversy. Most of the reluctance to accept fluoridated water can be ascribed to the widely known acute toxicity of fluoride. The effects of an excessive quantity of fluoride, however, are not in any way a deterrent to its use in fluoridated drinking water. It is the purpose of this discussion to document briefly the major evidence and observations which permit the use of fluoridated water by large population groups without hazard to the public health.

Prior to the association of fluoride in drinking water with dental health, harmful physiologic effects of excess fluoride had been observed in several areas of exposure of both man and domestic animals to fluoride. An industrial process in which a dust-borne fluoride mineral (i.e., cryolite) was encountered by the workmen, fluoride in the gaseous effluent of certain industrial plants, as well as an excess of fluoride in the mineral nutrition of domestic animals, all have created major fluoride health problems. An elevated fluoride content of

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drinking water became a public health problem when it was found to be the cause of mottled enamel and when excessive amounts of fluoride in drinking water caused disabling skeletal defects. Much of the basic research on the chronic physiologic effects of fluoride was motivated by these several areas of fluoride exposure.

For precision and quantity of the data on the physiologic effects of chronic fluoride toxicosis, the experimental results on domestic and laboratory animals exceed all other sources of information. However, because the absolute quantities of fluoride studied were often relatively large, an unequivocal application of these research data to water fluoridation is frequently not justified. Nonetheless, unquestionable evidence as to the organs and tissues of the body which are particularly sensitive to excess fluoride was made available through this extensive research preceding water fluoridation. The solution of problems connected with the public health aspects of water fluoridation was inestimably benefited by this prior information on the physiologic effects of fluoride.

SOURCES OF FLUORIDE

As a general rule the daily consumption of drinking water containing 1.00 ppm or more fluoride is the major source of the total fluoride in the average daily diet. With estimates of the average intake of drinking water by adults varying from 1200 to 1500 cc. daily, and with water fluoridated at the optimal level of 1.0 ppm fluoride, upwards of 1.2 to 1.5 mg. of water-borne fluoride will be consumed daily. Add to this an approximate 0.2 to 0.3 mg. of fluoride in the daily food, and the total daily fluoride intake amounts to 1.4 to 1.8 mg. While the great majority of ordinary foods as consumed contain approximately 0.2 to 0.3 ppm or less of fluoride, notable exceptions are tea and sea foods. Better grades of tea may contain 75 to 100 ppm of fluoride—a cup of good grade tea contains about 0.1 mg. of fluoride. Fresh and canned fish may contain from 2.0 to 12.0 mg. of fluoride per pound. Milk contains about 0.1 to 0.3 ppm of fluoride and the level remains practically the same regardless of the dairy cows' fluoride intake. An excessive fluoride exposure may increase slightly the fluoride in cows' milk.

The quantities of the total daily fluoride provided by fluoridated water and the food are, therefore, very small indeed. This factor of quantity of fluoride ingested in the use of fluoridated drinking water is extremely important. It is all too often lost sight of in our attempts to resolve the health safety of water fluoridation. The following tabulations give some indication of the quantities of fluoride

ingested by children when the drinking water contains 1.0 ppm fluoride.

From the available data it appears that food-borne fluoride as well as water-borne fluoride is largely available for the body's assimilation. It should be emphasized also that there is no difference in the availability and metabolism of fluoride present as a natural constituent of many drinking waters and fluoride added in fluoridated drinking water. It may be of interest to mention that the fluoridation of drinking water is accomplished mainly by the controlled addition of sodium

TABLE 1. *Summary of Estimated Daily Intake of Fluoride from Food and from Drinking Water (Drinking Water Containing 1.0 ppm Fluoride and Dry Substance of Food Containing 0.1 to 1.0 ppm Fluoride)*

AGE	BODY WEIGHT	DAILY FLUORIDE INTAKE			
		FROM DRINKING WATER	FROM FOOD	ACTUAL DAILY INTAKE	DAILY TOTAL RATE
yr.	kg.	mg.	mg.	mg.	mg./kg. body weight
1 to 3	8 to 16	0.390–0.560	0.027–0.265	0.417–0.825	0.026–0.103
4 to 6	13 to 24	0.520–0.745	0.036–0.360	0.556–1.105	0.023–0.085
7 to 9	16 to 35	0.650–0.930	0.045–0.450	0.695–1.380	0.020–0.068
10 to 12	25 to 54	0.810–1.165	0.056–0.560	0.866–1.725	0.016–0.069

fluoride or sodium fluosilicate to the water. Recently, progress has been made on the use of a mixture of calcium fluoride and alum.

FLUORIDE ELIMINATION

The most characteristic feature of fluoride biochemistry in human exposure is its accumulation in skeletal and dental tissues. It is for this reason more than any other that prolonged periods of excessive fluoride ingestion will become incompatible with physiologic safety, unless this ingested fluoride is eliminated from the body. Resolution of problems of cumulative toxic skeletal fluorosis have followed several lines of study. Obviously a foremost consideration was the elimination of fluoride from the body. Related to the fluoride content of drinking water, a comprehensive survey of urinary fluoride excretion was made prior to water fluoridation. Upwards of 90 per cent of the fluoride ingested in drinking water that naturally contained up to 4.5 ppm of fluoride was found to be excreted in the urine. A remarkably close

correlation exists between the fluoride concentration of urine and the fluoride content of drinking water.

The relation between fluoride in drinking water and the urinary fluoride excretion applies equally to a natural fluoride water and fluoridated water. Thus, a survey has been made of the fluoride in the urine of individuals of different ages who were drinking water fluoridated to approximately 1.0 ppm with sodium fluosilicate (Montgomery County, Md.) or with sodium fluoride (Grand Rapids, Mich.).

In the case of Montgomery County adults, the water fluoride and the urinary fluoride concentrations became virtually equal within one week after introduction to the fluoridated water. In school children aged 5 through 14 years (Montgomery County) and 6 through 17 years (Grand Rapids), approximately 3 to 5 years elapsed before the concentration of fluoride in the urine reached that in the drinking water. The difference in this response of adults and children during the initial period of exposure to a fluoridated drinking water suggests that the maturity of skeletal tissue influences its capacity to retain fluoride. These results give no evidence of an essential difference in the urinary elimination of fluoride ingested either in naturally fluoridated water, in water fluoridated with sodium fluoride, or in water fluoridated with sodium fluosilicate.

When an appreciable quantity of fluoride (5.0 mg. as sodium fluoride) is ingested at one time, it is eliminated rapidly in the urine, particularly during the following first hour.

The reduction in the fluoride content of the drinking water of Bartlett, Texas, from a high of 8.0 ppm to a little more than 1.0 ppm, provided an opportunity to obtain evidence of the elimination of fluoride from human skeletal tissue. It was ascertained in these studies on residents of Bartlett, Texas, during a period of 27 months following the reduction of fluoride in the drinking water, that the fluoride in the urine gradually decreased from as much as 8.0 ppm to approximately 2.0 ppm. The urinary fluoride values were considerably higher than would be expected for a corresponding group with no prior exposure to high levels of fluoride. The data indicate, therefore, that fluoride previously stored in the skeleton was being mobilized. There was some evidence that mobilization was more rapid in children than in adults.

There is other substantial evidence concerning the elimination of fluoride from the body via the urine and feces as well as the body perspiration. Five young adult men have served as subjects for studies of complete balances of fluoride in which the quantitative intake of fluoride in various forms was balanced against the fluoride eliminated in the urine, feces and body sweat. It was found that there

was no significant retention of fluoride in the bodies of these young men when the total daily fluoride ingested did not exceed 4.0 to 5.0 mg. daily. The data indicate that this amount of fluoride, at least, may be ingested daily without an appreciable hazard of the body storage of fluoride. In this study it was also found that the body sweat contained 0.3 to 1.8 ppm of fluoride and thus became an important means for the elimination of fluoride. The body's absorption of fluoride was dependent on the solubility of the fluoride ingested. Thus the fluoride ingested as calcium fluoride, cryolite and bone meal was absorbed appreciably less than fluoride ingested in Galesburg, Illinois, water (1.8 to 1.9 ppm fluoride). In the case of the ingestion of insoluble fluorides there is an increased elimination of fluoride in the feces.

It is quite apparent in the light of the above studies, as well as from other evidence, that the fluoride ingested by the use of fluoridated water is effectively eliminated from the body particularly via the urinary excretion. This fact of fluoride metabolism is an essential safeguard and preventive against the accumulation of toxic quantities of fluoride in skeletal tissue.

DEPOSITION OF FLUORIDE IN THE HUMAN BODY

The occurrence of fluoride in the animal body has been studied extensively in both laboratory and domestic animals. Similar data on man are quite limited, for obvious reasons. The presence of fluoride in human bones, cartilage, teeth, soft tissues, blood, bile and saliva will be discussed in this section.

Bones

A recent study of the deposition of fluoride in bones which have also been examined histologically furnishes very valuable information regarding the levels of fluoride tolerated in bone without any harmful effects. Roholm found approximately 0.21 to 0.89 per cent fluoride in the bones of two cryolite workers whose skeletal tissues showed evidence of increased calcification and trabeculation. Osteosclerotic changes were observed roentgenographically in two other persons whose bones contained 0.97 to 1.50 per cent fluoride and 0.46 to 0.50 per cent fluoride, respectively.

To add substantially to the very limited previous data, a rather comprehensive survey of the fluoride content of bones of persons exposed to drinking waters containing from 0.1 to 4.0 ppm fluoride was completed within the past year at the National Institute of Dental

Research. In addition, a number of bones were obtained at autopsy from the body of a person who had resided for at least 34 years in Bartlett, Texas, while the drinking water contained 8.0 ppm fluoride. The bones analyzed for fluoride were also examined histologically and thus afforded an evaluation of the relationship between fluoride concentration and microscopic change. The fluoride analysis of some

TABLE 2. *Ash and Fluoride Concentration of Skeletal Tissues of Individuals Receiving Drinking Water Containing 0.1 to 8.0 ppm F*

		COMPOSITE DATA (DRY, FAT FREE BASIS)				
F concentration in drinking water	(ppm)	<1.0[a]	1.0[b]	2.6[c]	4.0[d]	8[e]
Age	(yrs.)	55.5	75.6	65.9	56.0	78
Residence	(yrs.)	28.1	21.5	32.9	21.3	34
Iliac crest	No.	20	4	25	4	1
	% Ash	57.4	61.2	59.7	59.9	67.5
	% F	0.041	0.138	0.267	0.413	0.577
Rib	No.	30	4	27	4	1
	% Ash	58.8	57.4	59.7	57.5	66.9
	% F	0.050	0.139	0.257	0.398	0.630
Vertebra	No.	31	5	27	4	1
	% Ash	49.0	50.0	48.3	50.7	59.5
	% F	0.054	0.160	0.286	0.411	0.540

[a] Washington, D. C., Baltimore, Md., New York City, San Antonio, Texas.
[b] Grand Rapids, Mich.
[c] Colorado Springs, Col., and Amarillo, Texas.
[d] Lubbock, Texas.
[e] Bartlett, Texas.

188 bones from 70 individuals is presented in Table 2. To summarize these data it may be noted that:

1. The concentration of fluoride in bones increased in an essentially linear fashion with an increase of fluoride up to 4.0 ppm in the drinking water.

2. For a given level of fluoride in the drinking water, the three bones studied, i.e., the iliac crest, rib and vertebra, contained similar concentrations of fluoride.

Cartilage

In the course of the previous study, intervertebral cartilage became available for analysis. This tissue, containing about 2 per cent fat,

4 per cent ash and 5 per cent calcium, is essentially non-calcified. It was found that the fluoride content of the dry, fat-free cartilage from persons ingesting water containing <1.0, 1.0, 2.6, 4.0 and 8.0 ppm fluoride was 0.003 per cent, 0.004 per cent, 0.004 per cent, 0.007 per cent and 0.011 per cent fluoride, respectively. This very limited retention of fluoride by this tissue is in striking contrast with that retained by the bones.

Teeth

The teeth of persons exposed to drinking water containing 0.0 to 0.3 ppm fluoride contain about 0.010 per cent fluoride in the enamel and about 0.024 per cent fluoride in the dentin. Recent work has shown that enamel fluoride is highest on the surface and decreases with depth. Where optimal levels of fluoride are present in the drinking water, namely 1.0 ppm fluoride, the enamel and dentin contain 0.013 per cent and 0.039 per cent fluoride, respectively. Concentrations as high as 0.106 per cent and 0.214 per cent fluoride have been found in enamel and dentin, respectively, where the drinking water contained 7.6 ppm fluoride. There appears to be no clear difference in the fluoride content of sound and carious teeth. In general, the severity of mottling is associated with an increased concentration of fluoride in the teeth, although this relation may be affected by other factors.

Soft Tissue

Whereas calcified tissues by their very nature become extensive depositories of fluoride, this is not the case with soft tissues which do not ordinarily calcify. Indeed it has been shown that approximately 96 per cent of the fluoride retained in the animal body is found in the bones and teeth, leaving a very small quantity to be retained in the soft tissues. Satisfactory data on the fluoride analysis of soft tissues are very meager, primarily on account of the technical difficulties involved in making an accurate analysis of the extremely small quantities of fluoride present. The most to be said at this time on the subject is that progress is being made in the analytical procedure and a certain amount of the data is valuable for comparative purposes. Specimens of heart, liver, lung, kidney, spleen, and aorta obtained from persons ingesting drinking waters containing up to 4.0 ppm of fluoride have been analyzed for fluoride. The persons supplying these specimens are the same as those who supplied the bone specimens for fluoride analysis and histologic study previously referred to. The preliminary fluoride data thus far have not indicated variations

in fluoride content of soft tissues which could be attributed to the fluoride content of the drinking water. On the fresh basis, most soft body tissues, with a few exceptions, contain about 1.0 ppm or less fluoride. The aorta, which tends to become calcified, contained 2.1 to 37.9 ppm fluoride.

Blood, Bile and Saliva

Fluoride is present in blood, bile, and saliva, and probably in other extracellular fluids at a very low concentration approximating 0.1 ppm fluoride. The level of fluoride in these body fluids does not change appreciably with an increase in the fluoride concentration in the drinking water. It has been shown that the fluoride content of the saliva is very little affected by the fluoride in the drinking water and is not sufficient to suggest that it is a factor in the prevention of dental caries.

In evaluating the significance of the occurrence of fluoride in body tissues, there are the following facts to be considered. It is very probable that no body tissue is free of fluoride and all skeletal and dental tissues contain fluoride. The quantity of fluoride which is tolerated by any specific body tissue is undoubtedly a major factor in the over-all tolerance of fluoride, as has been previously emphasized. Answers to this latter problem have been forthcoming in the histopathologic studies of skeletal tissues and skeletal performance data correlated with the fluoride bone analysis. From all the available data it appears that skeletal tissue has an unusually high tolerance for fluoride. An increase in bone fluoride amounting to as much as 10 to 12 times the quantities normally present seems to create no health hazard. As much as 0.5 to 0.6 per cent fluoride therefore may be present in bones without harm. Quantities such as these do not accumulate in human skeletal tissues as a result of continued use of fluoridated drinking water.

While the fluoride content of soft body tissues usually remains a less reliable figure, it is equally true that no significant physiologic harm to soft tissues has been correlated with exposure to relatively high levels of fluoride in drinking water. The answer seems to be that very small quantities of fluoride are present and have no deleterious effect on soft tissue.

Specific mention perhaps should be made of kidney function in these regards. Urinary excretion of fluoride, as has been noted, is an essential feature of the body's metabolism of fluoride and any prolonged curtailment of urinary fluoride excretion might become hazardous. On the

other hand it has been stated with good reason that a kidney abnormality sufficient to impair normal fluoride excretion would probably prove fatal prior to any development of chronic fluorosis.

The other consideration to be mentioned concerns the kidney and its excretory function as related to a fluoride drinking water. The urinalyses included in the Bartlett-Cameron Study, the Newburgh-Kingston Study (see below) and other surveys have failed to reveal any kidney dysfunction attributable to the ingestion of fluoride water. Similarly, all the mortality statistics available indicate that exposure to a fluoride drinking water has no relation to kidney disease.

EFFECTS OF FLUORIDE ON HEALTH STATUS

In many areas throughout the world there are large populations of people who for many years have used drinking waters containing 1.0 ppm or more fluoride. In the United States approximately 1,903 communities, representing about 7,000,000 people, are now using a communal water supply which contains naturally from 1.0 up to 4.0 ppm of fluoride.

Many of these persons have been studied and, in addition, there is the early classic study by Roholm on chronic fluorosis produced by a dust-borne mineral, cryolite.

In this section the information pertaining to the health status of human subjects exposed to fluoride is presented in a more or less historical relation. For obvious reasons our greatest interest lies in results pertinent to populations exposed for many years to drinking waters which contain fluoride. Much of the more significant information pertaining to human experience with fluoride waters, however, has appeared in more recent years. Several of the significant studies remain to be published in detail in the very near future.

Skeletal Fluorosis

In 1937, Dr. Kaj Roholm, of Copenhagen, Denmark, described in his monograph, "Fluorine Intoxication," the effects of fluoride poisoning as seen in a group of workers exposed for prolonged periods of time to cryolite dust. Gross abnormalities in bones and failures in skeletal performance were apparent. The workers complained of rheumatic pains, stiffness in joints and particularly in the spine. Increased bone density varying with the length of the exposure to the cryolite dust was observed by x-ray examination.

A most important part of this survey of human fluorosis was an autopsy study on two persons exposed to cryolite dust 9 and 24 years,

respectively. The skeletal effects of this fluoride exposure, estimated to amount to 25.0 to 30.0 mg. daily, were characterized histologically as a diffuse osteosclerosis with pathologic formations starting in periosteum and endosteum. There was considerable formation of new bone from periosteum, and ligaments not normally calcified underwent a considerable degree of calcification.

Prolonged exposure to 10.0 ppm or more fluoride in drinking water also appears responsible for a chronic skeletal fluorosis characterized by rigidity of spine, stiffness and immobility of the joints and other symptoms similar to what was observed in the cryolite workers. These defects were reported to be endemic in certain areas of South Africa and India.

Dental Fluorosis

Dental fluorosis, frequently designated as "mottled enamel," is the only known water-borne disease in dentistry. As such it is limited to definite geographic areas. Dental fluorosis is unique also as an epidemiologic disease insofar as it results only if exposure to the causative factor, i.e., a fluoride water, is essentially continuous during the period of tooth formation. The importance of the relation of water fluoridation to the production of dental fluorosis is obvious and has received careful inspection and evaluation. A most interesting facet of the dental caries–fluoride water relationship, it may be recalled, is the fact that the beneficial effect of water-borne fluoride on dental caries was first observed incidental to the early studies on the cause of mottled enamel.

Dental fluorosis has been classified in five different grades depending on its severity. Most significant is the well documented evidence concerning the quantity of fluoride in drinking water which produces dental fluorosis in these different grades of severity. Grades of mottling defined for determining the mottled enamel index of a community are "questionable," "very mild," "mild," "moderate," and "severe." It is known that at a concentration of 1.0 to 1.5 ppm of fluoride in drinking water, "questionable" or "very mild" mottling occurs in a small percentage of the population. "Very mild" mottling is recognized with difficulty as small, opaque white areas scattered irregularly or streaked over the tooth surface. Principally observed on labial and buccal surfaces, very mild mottling involves less than 25 per cent of the tooth surfaces of the teeth affected. Small white areas are frequently found on the summit of the cusps. No brown stain is present.

The relation of mottled enamel to the fluoride content of drinking water is shown in Tables 3, 4 and 5.

TABLE 3. *Endemic Dental Fluorosis (Mottled Enamel) Related to Content of Fluoride in Drinking Water*

CITY	F IN PPM	NO. CHILDREN EXAMINED	COMMUNITY INDEX OF FLUOROSIS[a]	PREVALENCE (PER CENT)[b]
Colorado Springs	2.6	404	1.3	73.8
Galesburg, Ill.	1.9	273	0.7	47.6
Elmhurst, Ill.	1.8	170	0.7	40.0
Maywood, Ill.	1.2–1.5	171	0.5	33.3
Aurora, Ill.	1.2	633	0.3	15.0
Kewanee, Ill.	0.9	123	0.3	12.2
Peublo, Col.	0.6	614	0.2	6.5
Elgin, Ill.	0.5	403	0.2	4.2

[a] As described by Dean in Fluorine and Dental Health, 1942.
[b] Does not include a questionable diagnosis.

TABLE 4. *Dental Fluorosis in 12–14 Year Old Children of Grand Rapids, in 1944 as Compared with 1956 after Twelve Years of Continuous Exposure to Fluoridated Water*

YEAR	NO. OF CHILDREN EXAMINED	FLUOROSIS DIAGNOSIS						
		NORMAL	QUESTIONABLE		VERY MILD		MILD	
		No.	No.	%	No.	%	No.	%
1944	5074	4988	59	1.2	23	0.5	4	0.1
1956	755	685	44	5.8	26	3.4	0	0.0

TABLE 5. *Results of Dental Examinations of 438 Children in Newburgh and 612 Children in Kingston, Aged 7–14 Years, after 10 Years of Exposure to Fluoridated Water in Newburgh*

	NO FLUOROSIS	ENAMEL OPACITIES DUE TO FLUOROSIS			NON-FLUORIDE OPACITIES
		QUESTIONABLE	VERY MILD	MILD	
Newburg	360	46	26	6	36
Kingston	608	4	—	—	115

It is apparent from these data that a level of 1.0 ppm fluoride in fluoridated drinking water had little effect on the prevalence of mottled enamel. This agrees with the extensive epidemiologic surveys concerning the relation of natural fluoride water to dental fluorosis. There is no esthetic significance attached to a mild, very mild or questionable form of mottled enamel. It requires a trained eye to detect these degrees of mottling. The average dental practitioner would have difficulty finding them. None of these categories of dental fluorosis is disfiguring.

Skeletal Development

In conformity with the knowledge that calcified tissues are intrinsically retentive of fluoride, a great deal of data have been obtained pertaining to skeletal development and performance. Thus, the relation between the fluoride content of drinking water (containing 0.3 to 5.6 ppm fluoride) and the bone-fracture experience, height and weight of a large number of high school boys and young adult males was studied. No effect of the fluoride content of the drinking water was apparent from this survey. Fluoridated water also has had no effect on the height and weight of children. Pertinent to skeletal calcification and bone development also was a roentgenographic study of the hand and wrist of 2050 children aged 7 to 14 years exposed to 0.1 ppm of fluoride vs. 3.2 ppm up to 6.2 ppm fluoride in their drinking water. From the roentgenograms of these children the skeletal age was assessed and a quantitative index of ossification was determined. No evidence was obtained which would indicate that there was any adverse effect on the carpal bones or on their growth and development as a consequence of the continuous use of the relatively high fluoride drinking waters. Neither was there any indication that these large quantities of water-borne fluoride caused any hypercalcification or advanced skeletal maturity in these children.

The Bartlett-Cameron Study

A comprehensive survey has been made of the health of persons exposed to 8.0 ppm of fluoride present in the water of Bartlett, Texas, compared to a similar group of individuals exposed to 0.4 ppm fluoride in the drinking water of Cameron, Texas. The participants had resided in these two towns for at least 15 years when first examined in 1943. A second examination was made in 1953. Included in this investigation was a full medical history, physical, dental and x-ray examination, and detailed urine and blood analyses. There was no tendency toward higher rates in these two population groups with respect to spe-

cific systemic abnormalities or laboratory findings, excepting a higher incidence of dental fluorosis in Bartlett (8.0 ppm fluoride). The difference between the age-corrected death rates of the two groups was not statistically significant. Thus, no clinically significant physiologic or functional effects could be attributed to a prolonged ingestion of drinking water containing as much as 8.0 ppm of fluoride. With regard to deleterious bone changes, none were produced by ingestion of this high fluoride water. There was no unusual incidence of bone fractures, arthritis, hypertrophic bone changes, or exostoses, or interference with fracture healing. There were no cases of "poker spine" and no associated functional or systemic effects.

It may be noted that the excessive fluoride in this water supply did produce roentgenographic evidence of bone changes in 10 to 15 per cent of the Bartlett population group. However, these changes were slight, often difficult to recognize and frequently equivocal in degree.

The Newburgh-Kingston Study

In 1945 the water supply at Newburgh, New York, was fluoridated to a level of 1.0 to 1.2 ppm fluoride. The water of nearby Kingston remained unfluoridated as a control city. A comprehensive 10 year study of 500 Newburgh children and 405 Kingston children was reported in December, 1955. Annual medical examinations of the children and roentgenograms of the right wrist, both knees and lumbar spine were made to check the growth and development of these children over a ten year period. In addition, blood counts, urine analyses, and examinations of eyes and ears were included. A final analysis of all the data showed there were no differences of any significance (except for caries incidence) in the two groups of children, one having used a fluoridated water, the other a practically fluoride-free water.

Pathologic Studies in Man

Exposure to 2.5 ppm Fluoride in Drinking Water. One of the better known cities of the United States whose community water supplies contain in excess of 1.0 ppm of fluoride is Colorado Springs, Colorado. For many years approximately 2.5 ppm of fluoride have been present in this city water. Results of a series of 904 necropsies performed in Colorado Springs during the years 1947–1953 have been tabulated and analyzed statistically. Since this initial study paid no special attention to the bones, a subsequent study including a detailed examination of the bones was completed between 1955 and 1957. The necropsy protocols and the diagnoses were classified according to

(*a*) major cause of death, (*b*) contributing causes unrelated to the major cause, and (*c*) incidental pathology. Tabulated according to duration of residence in Colorado Springs, the data were analyzed statistically.

There were 334 individuals who had resided in Colorado Springs more than 20 years; 130 residents from 5 to 20 years; 188 residents under 5 years.

A final statistical analysis of the pathologic observations did not reveal any significant effects of a prolonged residence in the Colorado Springs environment.

Exposure to 1.0–4.0 ppm Fluoride in Drinking Water. The bone specimens for this study were obtained at necropsies performed in Grand Rapids, Michigan (1.0 ppm fluoride added as sodium fluoride), Colorado Springs (2.5 ppm), Amarillo, Texas (2.8 ppm), and Lubbock, Texas (4.0 ppm). There was a minimum of 10 years of use of these fluoride waters by these individuals. There were 24 cases from Colorado Springs, another 13 cases were from the other localities. The ages ranged from 36 to 90 years.

Thirty-three persons from non-fluoride areas served as controls, ranging in age from 21 to 87 years. The bones examined were the body of a lumbar vertebra, a portion of the iliac crest, and the sixth rib. The lumbar intervertebral cartilage and some specimens of sternum, calvarium and femur were also studied. In all, a microscopic examination was made of approximately 100 bone specimens of persons exposed to water containing 1.0 to 4.0 ppm of fluoride, and 94 bone specimens were provided by persons having less than 0.6 ppm of fluoride in their drinking water.

As a result of these microscopic bone studies it became apparent that the fluoride content of the drinking water had had no effect on the histologic structure of the bones. There were microscopic changes in the bones and joints associated with aging and other conditions, but these showed no relation to the fluoride ingested in the drinking water.

In a preceding section of this discussion there is a report of the fluoride content of the majority of these same bone specimens. As noted there, the quantity of fluoride in these bones was greatly increased by the fluoride drinking water. Even with this greatly increased fluoride content, the bones showed no abnormal structures.

MORTALITY STATISTICS

A comparison of the mortality data of various populations furnishes an important index of their general health. Recently a number of care-

fully controlled studies have obtained mortality rates for heart disease, cancer, nephritis, diabetes, extracranial lesions and cirrhosis of the liver among communities using essentially fluoride-free drinking water and those using waters containing fluoride naturally present or added in controlled amounts.

In one study the mortality statistics were analyzed for 32 cities whose water supplies contained more than 0.7 ppm fluoride from

TABLE 6. *Mortality Rates per 100,000 Population (Adjusted for Age, Race and Sex)*

DEATH	"FLUORIDE" CITIES	CONTROL CITIES
Heart disease	354.8	357.4
Cancer	135.4	139.1
Intracranial lesions	111.5	104.8
Nephritis	21.9	26.9
Cirrhosis of the liver	6.6	8.2
All causes	1,010.6	1005.0

TABLE 7. *Ratio of Recorded to Expected Deaths in Five Cities Ingesting a Fluoridated Drinking Water*

CITY AND YEAR OF FLUORIDATION	YEAR	NUMBER OF DEATHS		RATIO OF RECORDED TO EXPECTED DEATHS
		RECORDED	EXPECTED	
Grand Rapids 1945	1940	1643	1674	0.98
	1950	1803	1764	1.02
Sheboygan, Wisc. 1946	1940	394	380	1.03
	1950	383	416	0.92
Evanston, Ill. 1947	1940	611	660	0.93
	1950	672	765	0.88
Madison, Wisc. 1948	1940	546	612	0.89
	1950	652	762	0.86
Charlotte, N.C. 1949	1940	806	782	1.03
	1950	964	933	1.03

natural sources. Each of these cities was randomly paired with a neighboring city containing less than 0.25 ppm fluoride in its water supply. The total population for all cities exceeded two million. The death rates, adjusted for age, sex and rate, are presented in Table 6; they show no significant differences related to fluoride in the drinking water.

In another study, the mortality experience in five cities was compared before and after institution of fluoridation of the water supplies

to 1 ppm fluoride. The cities were fluoridated during the period 1945–1949 and the number of deaths (exclusive of accidents, suicide, and homicides) in 1940 and in 1950 was recorded. These were compared with the expected deaths using the U. S. age-race-sex mortality experience as a standard. A significant change in the ratio of recorded to expected deaths for the two periods 1940 and 1950 would then indicate that some variable other than age, race, sex and declining mortality for any reason had some influence. As shown in Table 7, there was no significant change in the ratio of recorded to expected deaths between 1940 and 1950.

These statistics thus indicate that no relationship existed between mortality experience and the presence of fluoride in drinking waters, whether naturally present or mechanically added. These data provide additional evidence that fluoridation of a water supply to 1.0 ppm fluoride presents no health hazard.

SUMMARY

A discussion is presented on the physiologic effects of fluoride as related to water fluoridation. The data pertain essentially to clinical and epidemiologic studies and mortality statistics based on human population groups. Because of the widespread occurrence of fluoride in many community water supplies, many thousands of human subjects have been exposed to fluoride in drinking water for long periods of time prior to the advent of water fluoridation. The health status and studies on clinical material obtained from these large population groups exposed to natural fluoride waters as well as to fluoridated waters have given no evidence that a health hazard will arise owing to a level of 1.0 ppm fluoride in drinking water. Highly significant dental health benefits resulting from the use of fluoridated drinking water have been conclusively established.

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The Diabetic Dental Patient

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In recent years accomplishments in dentistry have revealed that this branch of science in cooperation with the medical profession has made innumerable advances, not only in the treatment of oral disorders but also in preventive dentistry. That there is a close relationship between these health specialities is indicated in the physician's physical examination of the patient's oral cavity—teeth and surrounding structures —which is in the area of special competence of the dentist, and in the dentist's diagnosis of diabetes by oral lesions, which is in the field of the physician's special interest.[5]

It is apparent that these two medical specialities are essential to each other and that the physician and the dentist working together have created a better understanding of oral medicine and its relationship to general physical disorders. The results of this coordination or mutual understanding have been for the betterment of mankind.

The dentist is certainly aware of the increased incidence of oral disorders in diabetes. He ought to realize, too, that his role in diabetes becomes greater with the increase in the number of diabetics. Thus, if one observes the literature on diabetes, especially its incidence in our country as well as throughout the world, one will note that diabetes constitutes a major health problem. According to Wilkerson,[12] in 1953 it ranked eighth as a cause of death in the United States. It is also of interest to note that in 1950 approximately 100,000 new cases of diabetes were discovered, while in 1954 there were approximately 2,000,000 known cases of living diabetics.

What is of great concern to the medical profession is the 1,000,000 or more unrecognized cases who do not have the benefit of adequate medical care. This observation becomes more serious when one realizes that this proportion of unrecognized diabetics continues to rise; it is estimated that the diabetic population is increasing at a rate twice that of our total population.[12]

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Based upon statistical observations, it is anticipated that within another five year period diabetes (including associated vascular diseases) will rank third as a cause of death for the entire population of the United States.[6] This trend is recognized from the earlier observation of the incidence of death from diabetic coma compared with that from cardio-renal-vascular disease in the pre- and post-insulin periods. Thus the incidence of death from coma from 1898 to May 31, 1914 (pre-insulin era) was 63.8 per cent, whereas that from cardio-renal-vascular disease was 17.5 per cent; from January 1, 1944 to April 27, 1951 (insulin—Charles H. Best era), deaths from coma were 1.8 per cent while the deaths from cardio-renal-vascular disease had risen to 70.8 per cent. Based upon the present mortality rate, it is predicted that by 1980, if the mortality continues to rise, deaths from diabetes will be surpassed only by deaths from heart disease.[6]

To a measurable degree insulin has conquered diabetic coma and increased the life expectancy of a diabetic, but the circulatory complications, as previously mentioned, are graver, affecting the usefulness of man either partially or completely as well as taking his life. These vascular complications affect the most vital parts of a diabetic's body —his eyes, heart, kidneys and lower extremities.

In our own metabolic ward at Philadelphia General Hospital, a city-supported institution where the patients of the lower income group are cared for, we admitted 293 patients during 1957, of whom 123, or slightly less than one-half, suffered from vascular degeneration such as gangrene or ulcer of the lower extremities, or cardio-renal diseases.

When a disease, with its resultant devastating effects, becomes so widespread, it becomes the duty of the various branches of medicine, including dentistry, to combine their knowledge for the following reasons: first, to search for the increasing number of unknown diabetics so as to give them the benefits of adequate medical care; second, to give sufficient medical care (i.e., maintain good control of the diabetes) to the known diabetics.

It is apparent that the dentist is in an excellent position to help detect many of the unknown diabetics who seek oral treatment as well as to correct oral disorders in cooperation with the patient's physician. Present-day dentistry is not only concerned with tooth repair or replacement, but also with the condition of the supporting structural tissues of the teeth as well as with the state of the oral cavity.

Sir William Osler's statement that the oral cavity is a mirror of the rest of the body was doubtless an expression of the fact that the oral tissues are unusually sensitive indicators of the general physical condition of the person. Thus, diseases of the oral cavity caused by such drugs as bismuth, mercury, and antibiotics; the infectious, mem-

branous and catarrhal types of stomatitis; Vincent's infection, leukoplakia, cancer, syphilis, communicable diseases, blood dyscrasias, including the anemias; excessive exposure to radioactivity; infections arising from the teeth and affecting the jaws, maxillary sinus and lymph nodes; and other diseases associated with dermatologic, metabolic (diabetes mellitus) and nutritional conditions, may affect the functions of the entire body and often may be the initial lesions that give an inkling of an existing systemic disease.[9]

Before discussing the close association of oral disturbances with diabetes mellitus, a general knowledge of the etiology, symptoms and signs of the disease will enable the dentist to interpret more intelligently dental or oral diseases associated with diabetes.

The true etiology of the vascular conditions associated with diabetes is still unknown. There are many theories advanced by the various schools of thought to help substantiate their clinical findings of the close association of vascular degeneration with diabetes and diet. Since this is a controversial issue, we can say only that we are still in a quandary concerning the true cause of the associated vascular diseases in diabetes.[9]

We are cognizant of the fact that with increased incidence of diabetes in all classes of people throughout the world, diabetic coma is no longer a problem in the presence of insulin therapy. But the real issue that faces the individual with diabetes today is vascular complications. How can they best be controlled? This is our challenge.

THE IMPORTANCE OF THE DIABETIC HISTORY

The careful taking of the patient's personal and family history as it relates to diabetes should be incorporated in all dental offices as a routine procedure. The evaluation of the oral cavity cannot be properly conducted without taking into consideration the general physical condition of the patient.

If a patient has a family history of diabetes or presents symptoms or signs of diabetes, and if he is not under a physician's care, either one of the more recent simple laboratory urine tests for sugar should be made or the patient should be referred to a physician for discussion of the dentist's findings. It is also the duty of the dentist to know whether the patient who has diabetes is adequately following his physician's instructions.

ETIOLOGIC FACTORS IN DIABETES

The consensus of opinion based upon laboratory and clinical findings is that the cause of diabetes mellitus is associated with a deficiency

of insulin. Whatever the etiology may be, it is still unknown. We do know that the beta cells of the islets of the pancreas secrete insulin. Whether the insulin is quantitatively or qualitatively deficient or whether it is neutralized by some other factor or factors unknown to us after its normal secretion by the pancreas is still a mystery. The fact remains, however, that whatever the various processes that affect the insulin mechanism, the end result is insulin deficiency.

Whatever it is that affects the insulin mechanism, diabetes mellitus is the result of insulin deficiency. Any person who has a family history of diabetes or who has a blood relative having diabetes should be strongly suspected and examined for the condition. Hereditary predisposition is considered of marked importance. A susceptibility to diabetes appears to be inherited as a mendelian recessive characteristic. It may be revealed in the immediate member of the family or in a distant relative, and it may not appear until late in life. It has been estimated that approximately one out of every four persons is considered to be a "diabetes-carrier."[3]

Obesity appears to be a very significant factor in diabetes. A large percentage, perhaps 40 to 80 per cent of the persons with diabetes, were originally overweight.

Associated with obesity we may mention overeating. Overeating per se is not to be considered a potent factor, but it should be realized that insulin stimulates appetite. Perhaps these persons over a long period of overeating may "exhaust" the insulin-producing beta cells in the islets of Langerhans of the pancreas and develop diabetes.

Recent studies have revealed that, in conjunction with obesity, the endocrine glands—pituitary, adrenals, thyroid—may stand in a causal relationship to diabetes. When one is aware of the increased incidence of diabetes in obesity and in overheight children, one cannot help thinking of the role of the endocrine system. Other factors that appear to be playing a significant role in diabetes are gallbladder or biliary diseases and trauma. Its increased prevalence in patients past middle life and in women has been observed by some investigators in those patients who have been on increased fat diets.

SYMPTOMS AND SIGNS OF DIABETES

The most characteristic symptoms are increased thirst, urination and appetite. These symptoms are usually accompanied by a gradual or rapid loss of weight and a general weakness. Other symptoms of which the patient frequently complains are pruritus, local or general, disturbed vision, "heavy" sensation or tiredness, numbness and tingling sensation in lower extremities, and susceptibility of skin to slow-healing ulcers, carbuncles or furuncles.

SIMPLE TESTS IN DIABETES

Practical laboratory examinations of urine for sugar, proteinuria and ketosis are not time-consuming and can easily be performed by the busy dentist.[9] The materials necessary to make these newer simple tests are available at the various retail pharmaceutical stores.

Tests for Sugar in Urine

Tes-Tape (urine sugar analysis paper; Eli Lilly & Co.) is a special paper impregnated with the enzymes of glucose oxidase and peroxidase, and an oxidizable substrate, ortho-toluidine. When the paper is moistened with urine containing glucose, a blue color develops. This test is specific for glucose and will detect as little as 0.1 per cent glucose in the urine. (Fuller details are explained in the compact containing the material for the examination.)

Clinistix (reagent strips, specific for urine glucose; Ames Co., Inc., Elkhart, Indiana) are used in another of the more recent simple tests for glucose in the urine. The reagent strips for mak'ng the examination can be purchased at drug stores in packets of 30. The strips are enzyme-impregnated test paper for determining sugar (glucose in the urine).

The test end of a Clinistix strip is placed in the urine or in the urine stream, or moistened with a drop of urine, and then inspected. Color changes will determine the presence of sugar. (Details of the examination are enclosed in the purchased packets.)

Denco Sugar Test (Denver Chemical Mfg. Co., New York City). In this test a small amount of powder about the size of a ten-cent piece is gently shaken from the glass tube upon a piece of paper. A small drop of urine to be tested is placed in the center of the cone-shaped heap of powder. Color changes in the powder will be noticed within a few seconds (less than 30 seconds) and indicate the percentage of glucose present. (Detailed description of the test is enclosed in the purchased material.)

Tests for Ketosis

It is not uncommon for dental care to be sought by diabetics who have neglected their routine care or who have developed acidosis following an oral infection. Under such conditions, when urine is strongly positive for glucose, the dentist ought to be able to make one of the newer simpler, non-time-consuming tests for ketosis.

Ketostix (Ames Co., Inc., Elkhart, Indiana) are used in a new simplified dip-and-read test for the detection of ketonuria (ketosis). They

are paper strips coated on one end with chemical reagents that react with ketone bodies. The method is simple. Dip the test end of a strip in urine or briefly pass it through the urine stream. After one minute compare the color of the wet end with a color chart enclosed in the compact. Color changes will determine the amount of ketone bodies present. (Fuller details are described in the purchased material.)

Denco Acetone Test (Denver Chemical Mfg. Co., New York City). In this test a small amount of the powder (the size of a dime) is placed on a piece of paper, generally in a cone-shaped pile. With a medicine dropper, two or three drops of urine are placed upon the powder. In less than a minute a chemical (color) reaction will occur. The intensity of the color change will signify the degree of acetone present.

Test for Proteinuria (Albuminuria)

This is another simple test that is gaining significance because of the increased incidence of renal and eye involvement in diabetes. One such colorimetric test employs Albustix reagent strips or Albutest reagent tablets (Ames Co., Inc., Elkhart, Indiana), which are two practical chemical forms of the same principle.

The technique of the Albustix reagent strip examination is simple and rapid. Dip the yellow end of a strip into urine or moisten it in the urine stream. Remove the strip and observe color changes. The color changes of the dipped end of the strip are compared with a color scale enclosed with the package to determine the presence or absence of protein (albumin).

There are other tests for albumin, acetone and sugar which can be obtained in various textbooks on laboratory procedures. The ones described above are simple and inexpensive. Since diabetics are taught these examinations, it ought to be mandatory for all dentists in cooperation with physicians to interpret more intelligently their true significance in relation to dentistry.

These tests are time-saving. The value of these urine examinations is apparent when it is realized that there are many persons with positive laboratory findings who present no significant symptoms or signs of diabetes. Since patients are taught to examine their own urine, there is no reason why the dentist should not insist that such tests be made, if the patient has no family physician and conditions warrant it. When urine is positive for sugar, ketone bodies, or albumin, the patient should be referred to the physician for discussion of his findings. The fact that diabetes is present is important to the dentist's care of the oral cavity. He can adjust his therapy of the gums or oral

lesions, extraction of teeth, or prosthetic service according to the patient's response to diabetic therapy.

COMMON ORAL LESIONS ASSOCIATED WITH DIABETES

The mucous membranes of the oral cavity are usually sensitive indicators of general physical disorders; conversely, diseases of the oral cavity may have a pronounced effect upon the body functions. These effects are readily understandable when it is realized that the condition of the oral mucous membranes is influenced to a measurable degree by the same physiologic processes that influence other parts of the body.

The oral lesions may often present suspicious signs which are suggestive of a metabolic, nutritional, or endocrine disorder possibly associated with uncontrolled diabetes, but which is not specific for the disease diabetes. The many disturbances created by uncontrolled diabetes are explicable when we realize that today diabetes mellitus is considered to be a syndrome or symptom complex, with a varied etiologic background characterized by impairment of the body's normal ability to metabolize or utilize food.[10] This impairment is dependent upon the condition of the insulin mechanism—an actual or relative deficiency of insulin brought on by a disturbance in the function of the islets of Langerhans of the pancreas, or by some interference with the action of insulin in the body tissues. Insulin is concerned not only with the carbohydrate metabolism, but also with the metabolism of protein and fat.

Thus one can readily understand why such oral signs and symptoms as dryness of the mouth, hyperemic and swollen gums and mucous membranes, burning sensations of lips, tongue and palate, and loss of filiform papillae on the tongue may be signs of avitaminosis frequently associated with uncontrolled diabetes. They may well represent oral manifestation of vitamin B complex deficiency.[1]

Observations have revealed that the incidence of caries in diabetic patients is no greater than in the non-diabetic.[6] A careful dental study at a diabetic camp for boys and girls showed that among 276 children aged 6 to 17 years, 15.2 per cent did not require dental care. It also revealed no increased incidence of missing, filled or carious teeth or of periodontal disease over that of a control group of non-diabetic children of comparable ages. Another group of investigators,[7] in their studies of the oral cavity in 149 treated diabetics, found such subjective symptoms and their tissue changes "as denture irritation, dryness of the mouth, loose and painful teeth, burning lips, tongue and palate, receding, bleeding and painful gums, tenderness at temporomandibular joint, loose and poorly fitting dentures, bad mouth

odors, swelling in the parotid region, indentation, fissuring, lobulation of the tongue and hypertrophy of the papillae; for the gingivae, edema, recession, hypertrophy, bleeding, pus formation."

According to Cohen,[2] the absence of increased salivary glucose levels in certain diabetics having the highest susceptibility to caries points to other factors in the physiology which may be involved in diabetes. His studies, over an extended period, of caries susceptibility of 27 young diabetics, aged 6 to 30 years, showed an accelerated rate of tooth decay with advancing age.

In view of the above observations as well as of the results of other clinical investigators, it appears that there are no specific oral signs or symptoms of diabetes. Similarly, a physical examination of a diabetic may not reveal any specific signs of diabetes.

Burket's[1] suggestive signs and symptoms may help the dentist in making a diagnosis of suspicious diabetes: (1) patient's complaint of a toothache in an otherwise clinically sound tooth; (2) increased number of new cavities formed during a given period of time; (3) periodontal disease as a possible early sign; (4) development of advanced periodontal disease with marked loss of the alveolar bone in a young patient; (5) an unusually rapid calculus formation in uncontrolled diabetes. With such symptoms or signs the dentist should not hesitate to consult the family's physician immediately. Such cooperation will give invaluable aid to the patient in helping to discover the disease in an early stage and perhaps in warding off some of the unfavorable complications.

GENERAL ORAL CARE IN DIABETES

No physical and laboratory examination of the patient is complete without a thorough investigation of the oral cavity. It is the duty of the physician to advocate dental consultation as a routine procedure for all of his diabetic patients. Since an adequate diet is a paramount factor in the treatment of a patient with diabetes, oral disturbances must be corrected to insure the proper mastication of food and aid its normal absorption and utilization, thereby helping to avoid avitaminosis.[9]

It is a common belief among many diabetics that when their blood sugar level is normal the diabetes is adequately controlled. But clinical observations have revealed that, in spite of the normal blood sugar level, many of the patients have evidence of associated progressive vascular degeneration such as retinopathy, coronary artery disease, or advanced renal disease (Kimmelstiel-Wilson disease). What the etiology may be is still unknown.[10] The fact remains, however, that the blood sugar level should not be taken as the sole reliable index to the

state of whole body metabolism without considering, or searching for, other unknown factors.

A diabetic patient with a normal blood sugar level may have many oral disorders associated with diet disturbances. Thus, it is not uncommon for such patients to complain of symptoms and signs of generalized avitaminosis such as swollen, hyperemic, tender gums which bleed easily; loose and sensitive teeth with multiple cavity formation; enlarged, raw-looking, sore tongue; general malaise associated with tiredness, mental depression, irritability; gastrointestinal symptoms such as "bloated" feeling in the stomach, "heart burn," constipation or loose stools; and impaired vision and itchy, scaly and swollen eyelids.[9]

After correction of the mouth disorders by removal of all foci of infection and the replacement of missing teeth with proper prostheses to insure correct occlusion and normal mastication of the prescribed diet, there often results alleviation of many of the symptoms and signs of avitaminosis. As a result there is often a better control of the diabetes, as evidenced by a reduction in the insulin dosage and sometimes its discontinuance.

ORAL SURGERY IN DIABETES

Oral surgical care (e.g., extraction of teeth) in the person with controlled diabetes is similar to that in a non-diabetic. It is the unfortunate person who is unaware of his diabetes, or who has uncontrolled diabetes, in whom complications such as acidosis or coma, delayed healing processes or localized osteitis may develop or may be precipitated by the extraction of teeth.

Preoperative Measures

That such complications do occur is sufficient reason for the dentist to take all available preoperative measures for adequate oral care of the diabetic in cooperation with the family physician. These can be accomplished in the following manner.

1. Be certain that the diabetes is adequately controlled. It is not uncommon for the patient to inform the dentist that his diabetes is stabilized. This information may be true, but rely on it only after you have consulted his family physician.

2. Make a careful oral examination and decide upon the number of teeth to be extracted. Consult the family physician as to the patient's general physical condition to ascertain the optimal time for dental extraction.

3. Treat existing periodontal disease. It is the consensus of opinion, and is advocated by Burket[1] and by Sweet,[11] that oral foci of infection such as pulpless teeth and periodontal disease should be given utmost consideration prior to surgery. One can readily understand the cause of increased transient bacteremias in diabetes following surgical intervention, if proper preoperative care is ignored. Therefore, if there are signs and symptoms of periodontal disease, it should be treated to help reduce the increased susceptibility to bacteremias as well as the severity of the diabetes.

It is not uncommon to observe patients with uncontrolled diabetes who have a periodontal abscess or gingival disease. In these patients the gingivae are often separated from the roots of the teeth, which are loose or movable, with increased cervical sensitivity. This situation provides a fertile field for the production of transient bacteremias. With the correction of the infection and the control of the diabetes, many of the oral changes become less pronounced; the teeth become less sensitive and less movable, gingivae approach the normal state in color and consistency, the tongue appears normal, and there is an absence of mouth odor of acetone.

Anesthesia

Oral surgical procedures are generally performed in the morning, 2 to 3 hours after breakfast and insulin, using local infiltration or block anesthesia such as procaine hydrochloride or lidocaine. Substances or agents containing epinephrine or Cobefrin are inadvisable because of the possibility of precipitating anginal symptoms or local adverse tissue changes.

If the condition of the oral cavity is such that the use of local anesthesia may help spread infection, it is advisable to consult the family physician regarding the type and use of general anesthesia. The type of general anesthetic generally employed for a short operation is nitrous oxide–oxygen. After the type of general anesthetic is decided upon, it is advisable to administer it to the patient in a fasting state, either before breakfast or 4 hours after breakfast.

Postoperative Care

When the patient regains consciousness immediately following the use of the general anesthetic, no food or fluid is given orally for 1 to 2 hours. After this interval, the patient is given ginger ale or strained orange juice, followed by the regular dose of insulin until the next meal, when a liquid or soft diet is given according to the diabetic formula.

Occasionally, signs and symptoms of hypoglycemic reactions are observed two or more hours after tooth extraction in patients who have been administered insulin. This condition is frequently signaled by blurred vision, impairment of speech, profuse sweating, twitching of facial muscles and extremities, or even by unconsciousness (insulin coma). The condition is generally corrected by giving the patient ginger ale or some form of sugar, plain or dissolved in water or in orange juice. If the patient is in insulin coma, intravenous administration of glucose is advisable.

The question of the use of antibiotics after extraction of teeth has been frequently discussed. Penicillin and other antibiotics are strongly advocated for diabetic patients following tooth extraction, especially in the presence of such definite infections as rheumatic, congenital, and arteriosclerotic heart disease. The question of the application of universal chemoprophylaxis must be thoroughly studied, especially when one observes the rarity of secondary bacterial infections following dental extraction and the increasing frequency of unfavorable or even fatal reactions to antibiotics.[4] It is our belief that the use of antibiotics is best restricted to specific conditions.

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Occupational Diseases of Dentists

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Occupational diseases are usually considered to be those which are peculiarly associated with specific occupations. Industry has recognized the importance of control of occupational hazards, such as chemicals, gases, flying particles, infectious agents, and atmospheric conditions. There are now medical specialists who devote their careers to the field of industrial medicine.[17] Dentists, on the other hand, conduct their practices without any employing agent or guiding hand safeguarding their health. Each individual practitioner's health is his own problem.

A survey of the causes of death among dentists (1951–1954)[24] showed that the mean age of death of dentists (age adjusted) was 69.1 as compared with 68.0 for the white male population over 24 years of age. When broken down into categories of cause of death, only diseases of the blood and of blood-forming organs (63 years vs. 68.2) and diseases of the skin (62.7 years vs. 64.8) showed lower mean ages of dentists in comparison with the white male population over 24 years of age. Diseases of the circulatory system accounted for 54.89 per cent of the deaths, and neoplasms, the next in rank, caused only 16.22 per cent. This study does not indicate any fatal disease which is peculiar to dentists but, since only 3,576 deceased dentists were included in the study, rates of death per thousand could not be calculated accurately. Since there were only 8 deaths from diseases of the blood and blood-forming apparatus (0.2 per cent) and 25 from leukemia and aleukemia (0.7 per cent), they are not significant causes of death among dentists.

One might ask how much attention dentists give to their own health problems. A survey[9] published in 1957 shows that 73 per cent of dentists had regular physical examinations on the average of one every 2 years, and that 98 per cent of dentists had had chest x-rays within the

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previous 6 months to 11 years, with an average of 2.1 years. Sixty-six per cent of the group had had electrocardiograms at an average of 2.8 years previously. It was further ascertained that 90 per cent of dentists had regular eye examinations at an average of 2.5 year intervals (1 to 15 year extremes).

There are certain specific conditions that might well be related to practice of dentistry but which represent hazards to health and to continued practice rather than causes of death. These include radiation, drug sensitivity, metallic poisoning, dust, ocular disease, orthopedic problems, circulatory disease and infectious diseases.

RADIATION

Radiation has been used in dentistry almost since the time of Roentgen. Doctor C. Edmund Kells, Jr., the famous New Orleans dentist, gave a demonstration of the use of x-rays in dentistry in July, 1896, and in 1903 he established an "x-ray laboratory." On August 6, 1945, an atomic bomb was dropped on Hiroshima and shortly the world was made aware of the "dangers" of radiation. The potential danger of radiation has been recognized by the medical and dental professions for over half a century, but Muller's demonstration[25] that radiant energy, used experimentally, could produce mutations became popularized when Muller received the Nobel prize for his research. These two unrelated scientific developments, atomic energy and radiation-induced mutations, have led to alarm. Yet radiation is valuable in diagnosis and in the treatment of disease. The undesirable effects are related to the characteristics of the radiation used, the dosage, use of filters, the amount of shielding, and the susceptibility of the individual. Dentists should be aware of the potential dangers of x-ray, its value in dental care, and its limitations.

The radiologist's average age at death is 5 years less than that of the average American male and they have 6 times as much leukemia as physicians not using x-ray.[30] A survey of radiologists (who stand behind protective screens), fluoroscopists, dentists, and medical specialists, suggests the need for caution on the part of dentists and their paradental personnel (Table 1).

Since the maximum safe tolerance level per week is now given as 0.3 r[32] and there is some effort being directed toward reducing this arbitrary figure to 0.2 r per week, it is evident that the dentist who is careless may be exposing himself to somewhat excessive radiation.*

* While recommending caution, the National Committee on Radiation Protection still more recently gave 0.3 r per week as the MPD for occupational exposure. (Arch. Int. Med., Sept., 1957.)

Another disturbing note is indicated by a survey of dental x-ray units,[5] which indicates that a large proportion have faulty shielding, or are used in such a way as to give excessive exposure to the operator.

Caster[5] has reiterated that a paper clip should be placed over a standard dental x-ray film and kept in the dentist's pocket for a week or two. Most dental films will produce a distinct image at 0.03 to 0.1 r. If the dentist or his associated personnel are receiving appreciable radiation from scatter, a detectable image will be present. If the dentist is engaged in radiology as a specialty he may be receiving more than 0.3 r per week. Every individual, whether engaged in dental practice or not, receives 0.1 to 0.2 r annually from natural sources, such as cosmic rays, earth radiation, body minerals and

TABLE 1. *X-Ray Exposure Survey in Boston**

NUMBER	SPECIALTY	R/WEEK
65	Radiographers	.04
72	Fluoroscopists	.18
11	Dentists	.20
12	Dermatologists	.25
4	Urologists	.47

* From Warren, reference 30.

structural materials as well as from luminous watch dials, television sets and "fall-out."[5]

The dentist, and his paradental personnel, must be careful *never* to hold films in the patient's mouth. Many dentists have lost fingers or developed carcinoma as a result of this careless habit. While it seems unnecessary to give this warning, every year more dentists are faced with amputation, carcinoma, or fear of these hazards because of carelessness. Moreover, the dentist and his assistants should never hold the tube or the cone during radiographic procedures. It is best that the dentist, or his assistant, step to the side of the direct beam of the x-ray at a plane slightly behind that of the patient, and to the limit of a 5 to 6 foot cord, before making each exposure. In a small office a protective screen (primary protective barrier) is recommended.

The dentist should be able to use his dental x-ray unit, if it is in good condition, without hazard, if he (1) never holds the film, (2) is never in the direct beam of x-rays, (3) never holds the tube housing or the pointer cone during exposure, (4) takes a position six feet away from the direct beam and lateral to it slightly behind the plane of the

patient, or uses a protective screen, (5) never uses hand-held fluoroscopic screens, (6) uses no larger field than clinically necessary, (7) uses a cone for all routine purposes,[32] and (8) uses the highest KVP available (up to 90 KVP) with a 1 to 2 mm. aluminum filter and a cutout lead diaphragm in the tube head opening.[2]

For further safety, some have recommended that the dental x-ray room be lined with ⅛ inch lead sheeting applied with lead nails, or that the chair be rotated so that the rays are directed out the window or toward an unoccupied area.[2]

DRUG SENSITIVITY AND CONTACT DERMATITIS

The dentist may be sensitive to contact with drugs or materials used in practice. Among the offenders are mercury, nickel, chromium, iodine, procaine, dyes, essential oils, soaps, acrylic resins, rubber, phenols, sulfonamides, antibiotics, and almost any other drugs in certain individuals. The lesions usually appear on the fingers or hands of the dentist.

Local Anesthetic Agents. It is extremely unfortunate when a dentist is faced with sensitivity to a local anesthetic, such as procaine, used routinely in his practice. A survey of 7,515 Navy dental officers[6] with 3,951 respondents indicated that 128 (3 per cent) were sensitive to procaine. Dermatitis was the chief complaint, although 10 developed urticaria. Only 4 were totally disabled. However, if the reported sensitivity rate of 3 per cent is representative of the total dental population, over 2,700 dentists can be expected to be sensitive to procaine. For most of those who are sensitive to procaine, the symptoms occur irregularly, and the attacks lasted for less than one week in 43 per cent of the Navy group. Changing to another type of local anesthetic may give complete relief. An ophthalmologist[8] has reported resorting to cocaine anesthetic for relief, although this procedure does not appear justified in dentistry. Patch testing of the skin by applying different types of anesthetic agents on unmedicated Bandaids, and observing the presence or absence of erythema after 24 hours, will give a clear indication of the dentist's sensitivity. Since procaine is a para-substituted compound and xylocaine is ortho-substituted, a dentist may be sensitive to one and not to the other. The possibility of sensitivity to the type of vasoconstrictor must be considered, too.

Acrylic denture materials may cause contact dermatitis. The hands, and even the entire arms, may show redness, scaling, dryness, or vesiculation. The sensitivity is due to the monomer and not to the cured denture material.[13] Smith and Bains[28] have demonstrated that water will leach out the water-soluble portion of the monomer in 12 to 36 hours

and that the remaining monomer probably is bound to long-chain molecules. Obviously the dentist and dental technician who handle the monomer, or dentures with free monomer, are likely to develop lesions if they are sensitive to the monomer. Simple patch testing on the skin will clearly indicate sensitivity or lack of sensitivity.

Nickel or chromium used in "stainless steels" may produce contact reactions. Thus, a dentist or a patient may be sensitive to a prosthetic or orthodontic appliance, or to instruments that are used in practice. Patch testing with grindings from the suspected appliance or instrument is indicated.

At times a dentist may be sensitive to a drug and, recognizing this problem, may resort to finger cots or rubber gloves. He may also, however, be sensitive to the rubber or to the powder used to permit easy application. In the latter instance, washing the gloves or cots and substituting a lubricant may be adequate to relieve the dermatitis.

Mercury has long been recognized as a substance provoking dermatologic response.[15] The mercury in many antiseptic agents, or in wet sterilizing solutions, may be the offender, or it may be free mercury used to make silver-mercury amalgams. Ever since the "Amalgam War" of the first half of the 19th century, the possible toxicity of mercury, as used in amalgam restorations, has been debated. Even as late as 1926, Stock, a German professor of chemistry, started a new controversy with copper amalgam as the primary target. An analysis of dental operating rooms and urinalysis of personnel indicates that the dental assistant is exposed to a higher concentration of mercury vapor than the dentist or patient and that copper amalgam results in a higher mercury vapor concentration than silver amalgam. Because of the possibility of developing a sensitivity to mercury, Frykholm[15] suggests that any spilled mercury be removed from floor joints or other places where it may have fallen, that weighing and trituration be performed on a stainless steel tray to facilitate recovering drops of mercury, that the squeeze cloth be kept in a closed jar, that amalgam never be kneaded in the hand and that the dental premises be adequately ventilated. These precautions are based on the knowledge that mercury is volatile at room temperature, and on analyses of vapor and urine. Although these are hygenic precautions and are worthy of careful consideration, Grossman and Dannenberg[16] found the amount of mercury vapor in 50 American dental offices to be slight but "non-toxic." The concentration of mercury vapor was proportional to the amount of mercury used by the individual dentist.

Any of a vast number of drugs may evoke dermatitis or urticaria. It is estimated that as high as 5 per cent of the population may be sensitive to any new drug. For this reason, if dermatitis or urticaria

develops a series of patch tests of new agents, including soaps and detergents being used by the dentist, is indicated.

The dentist should not overlook the fact that he is subject to other types of dermatitis, and in any cases of doubt a dermatologist should be consulted.

DUST HAZARDS

Dust inhalation may lead to pneumonoconioses. Silicosis is the most important of the pneumonoconioses and is a disease of the lungs due to inhalation of free or uncombined silica. Workers in flint factories, sandstone and granite workers, certain types of miners, pottery workers, metal grinders using wheels of sandstone, polishers and sandblasters are among the groups most exposed to dangers of silicosis.[17] Obviously, dentists who grind and polish are subject to the same risks if they are careless and do much polishing and grinding. The amount of free dust can be minimized by dust control through exhaust-type collectors, protective shields and wet methods. The dentist should use, as grinding and polishing agents, substances which are free of silica. Not all polishing agents are silica-free.[20]

The unnecessary inhalation of silica-free dust is not advisable, as a pneumonoconiosis with resultant reduction of available lung area may result. Kerr, Ramfjord, and Grape-Ramfjord[19] have shown that new and used airbrasive powder and powdered enamel and dentin are tissue irritants when introduced into the peritoneal cavities of animals. They also showed[18] that diffuse lesions could be produced in the lungs of animals inhaling airbrasive dust but pointed out that, due to the periodic slight exposure to a very low concentration of dust, the airbrasive technique does not produce a health hazard.

OCULAR DISEASE

The dentist's eyes are of primary importance in maintaining his usefulness in patient care. The dentist may wear glasses to relieve eye strain or to aid in correcting vision when there is a tendency for the eyes to be myopic, hyperopic or strabismic. As the individual ages the ability to focus on close objects decreases (presbyopia). In instances of myopia, hyperopia, or strabismus, simple lenses may be of great value, much as prosthetic dental devices, but they do not cure eye disease. In the presbyopic dentist, bifocal or even trifocal lenses may be necessary[31] because of the relatively frequent change of working distance that his practice demands. In others, there may be a need for reading glasses, working glasses, and glasses for general wear.

Most dentists are aware of the value of regular eye examinations.

It is indicated that 90 per cent of dentists have their eyes examined on the average of once every 2.5 years (extremes 1 to 15 years). Of dentists interviewed, 83 per cent wore glasses. Simple lenses were worn by 49 per cent, bifocals by 47 per cent and trifocals by 4 per cent.[11]

Even though a dentist does not need corrective lenses, plano lenses are recommended as a protection against flying particles or infected material.[27] Industry recognizes this important field and takes steps to prevent eye injury.[21]

The dentist should consider his environment from the viewpoint of optics. The type of light,[14] the walls, filters, and sunbreaks[22] are of extreme importance. He should also have regular examinations by an ophthalmologist so that disease may be intercepted as well as visual defects corrected. He should be prepared to take necessary steps to prevent eye destruction by acid or alkalis which may enter the eyes accidentally. Flooding with water is the primary first aid step, but treatment should never stop here.

ORTHOPEDIC AND PODIATRIC PROBLEMS

About one-third of dentists admit that they have "trouble" with their backs,[12] and 43 per cent of these men thought that dental practice was a contributing factor. The dentist, traditionally, stands at his chairside for much of his working day. About half of all dentists use an operating stool and many attempt to prevent back strain by posture control, exercise, or by special aids such as orthopedic shoes or floor mats.

The cervical spine is subject to pressure from poor chair posture. The large nerves coming off the spinal cord in this region may be traumatized, producing local neck pain, occipital headaches, shoulder pains, chest pain and pain in the arm. If the pain is precordial, and in the left arm and shoulder, it may simulate coronary angina.[23] The thoracic spine is less mobile, but disk protrusions may be a problem. The lumbar spine is mobile and receives the greatest daily stress. Small congenital defects may contribute, and herniated disks represent a distinct problem. The dentist's posture and corrective exercise may contribute to reduce backache, and use of an operating stool may serve to reduce contributory strain associated with long hours of standing.

It has been estimated that the dentist gives ten times as much wear and tear to the feet as do other members of the healing professions.[7] Corns and calluses may develop from external pressures of improperly fitted shoes or socks and from internal pressures of deformed or mal-

posed bones. Flat feet may develop from long standing in ill fitting footwear. The dentist should wear properly fitted footwear and, if flat feet develop, he should consult an orthopedist or podiatrist for the type and fit of shoes, not depending on self-prescribed "arch-supports." The dentist should rest his feet and elevate them when at rest.

CIRCULATORY DISEASE

Any increased susceptibility to circulatory disease in dentists is probably associated with long standing periods and improper posture. Although no data are available, the dentist probably is more subject to varicosities of the veins of the lower extremities than is the general male population. If varicosities occur, medical consultation should be sought immediately, as thrombophlebitis may be a complication.

INFECTIOUS DISEASES

The dentist is subject to disease communicated from his patients.[3] One of the most severe infections may be acquired through an accidental bite on the finger. Human bites are among the most dangerous of lacerations. The organisms, which grow in the mouth without invading the body and which even contaminate oral wounds without causing infection in most instances, may result in severely infected wounds on the body. If a dentist receives a bite on his hand or fingers he should immediately scrub it thoroughly and carefully with soap and water and have it dressed by a physician. It may be well to have prophylactic antibiotic therapy.

The dentist is likely to receive or transmit air-borne infections.[4] The upper respiratory tract infections, therefore, present a special hazard to dentists. In particular, the dentist who treats patients with active pulmonary tuberculosis must use caution. The patient with undiagnosed tuberculosis is even more dangerous.[4] The dentist must use an efficient mask and scrub carefully when treating a tuberculous patient. Oral rinsings from 300 consecutive dental procedures on 111 tuberculous patients were positive, in 43.7 per cent of the cultures, for human-type tubercle bacilli.[1]

The patient may transmit the common cold or influenza virus to the dentist by coughing, sneezing, talking or by simply breathing. Dentists who are susceptible to upper respiratory tract infection should wear masks or nasal filters when operating on patients with these infections.[4] About half of American dentists lose about 9 days per year from practice because of illness. Of these absences, 48 per cent were for colds and 28 per cent for "flu."[10]

Dentists may acquire syphilis during professional activities. The left hand is particularly likely to be infected, although such infections are rare. It is not feasible to have serologic tests on every dental patient, but questions designed to ascertain any possible history of syphilis should be included in the Health Questionnaire.[4,29] If a positive answer is received, the patient's physician should be consulted to learn the status of the disease and the possibility of transmission of syphilis or other complications during dental treatment. In early stages of syphilis the patient may have mucous patches, which are highly infectious, or he may have a spirochetemia. The dentist should be alert to the possibility of oral syphilitic lesions, should use tongue blades or gloves when making an exploratory oral examination, should keep the skin of his hands intact or protect areas of abrasion, should wear rubber gloves when working on a syphilitic patient unless assured by the physician that the patient is non-infectious, should immediately lay open any needle prick received while working on a syphilitic patient and rub in 33 per cent mercurous chloride ointment and have a serologic test at weekly intervals for 6 weeks and monthly tests for an additional year, and should have any indolent sores on the hands investigated by a physician. It is advised that the dentist not scrub his hands prior to or after working on a syphilitic but should soap without scrubbing. Scrubbing may produce minor abrasions.[26]

SUMMARY

The dentist is presented with hazards to his health in the course of his daily practice. He should be aware of the potential risks and take measures to prevent suffering disease, disability or discomfort that might result from them.

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Systemic Diseases in Children of Interest to the Dentist

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Children are brought to the dentist usually for a particular service which is primarily of a specialized and technical nature; namely, examination and treatment of the teeth. However, it is also the dentist's obligation to search for evidence of those diseases which affect the jaws, the contiguous soft tissues and the teeth. It is generally agreed that many of the oral conditions found in children are the result of systemic disease.

Dental caries is the most common of all diseases affecting children. While the local etiologic factors are the most prominent ones in dental caries, there is some evidence that vitamin D supplementation in children is beneficial in the reduction of caries incidence.

There are several diseases such as rickets and the erythroblastic anemias that affect the skull and jaws of children. A knowledge of these and other conditions will help the dentist to be of greater service to his patients. Space will not permit a discussion of all diseases affecting the skull and jaws, but the more important ones will be mentioned and discussed.

The most important group of systemic diseases affecting the oral tissues of the child are those which manifest themselves in the condition of the soft tissues, the tongue, the lips and the gums. In this group, among others, appear the hemophilias, diabetes, and the leukemias.

SYSTEMIC CONDITIONS AFFECTING THE TEETH

The teeth, like other parts of the body, are affected by disturbances of the endocrine systems. Tooth eruption and tooth development are delayed when the normal production of ***pituitary growth***

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hormone does not take place. The size of the teeth in pituitary dwarfs is apparently not affected; the crowns of the teeth develop according to the dwarf's chronologic age. However, the pulp, the roots and the supporting structures of the teeth are retarded, even when the patient is given intermittent hormonal treatment.

In cases of ***hyperthyroidism*** it has been noted that tooth eruption is much earlier and root development in the permanent teeth is greatly advanced. In ***hypothyroidism,*** hypoplastic defects in the developing teeth have been noted, and shortening of the roots with alterations in the dentin has been observed in other cases. The skeletal age and dental development are markedly retarded. Cheilosis, suggestive of riboflavin deficiency, has been noted also in some of these cases.

It has been observed frequently that patients with decreased salivary flow usually have rampant caries. In untreated cases of ***diabetes insipidus*** the mouth is dry and a small volume of saliva is secreted. For this reason, many patients with diabetes insipidus may exhibit evidence of rampant caries.

There are a few disorders which come under the general heading of congenital or developmental skeletal dystrophies that cause disturbances in the size of the teeth or the constitution of the hard tissues of the teeth. One of these is ***Morquio's disease,*** or hereditary osteochondrodystrophy. In this disease the teeth may be smaller because of thinner enamel. Usually there is no crowding of the teeth; actually, all of the teeth may be separated by small diastemas of equal width. The occlusion is acceptable and functional, as a rule.

In ***atypical chrondrodystrophy*** one may find missing or peg-shaped teeth and malocclusion. Both of these diseases are rare.

Osteogenesis imperfecta has received quite a bit of attention in recent years because it causes the glaring defect in the teeth known as odontogenesis imperfecta. In ***cleidocranial dysostosis,*** impacted, unerupted, abnormally shaped, missing and supernumerary teeth are common. Eruption of the teeth is delayed in cases of this disorder. Cleidocranial dysostosis is characterized by failure of formation of the clavicles and retarded closure of the sutures and of the fontanels. In addition, one can observe an underdevelopment of the facial bones, maxilla and mandible. In ***osteosclerosis,*** delayed and incomplete eruption of the teeth is common. In some of these cases the crypts in which the permanent teeth were formed fail to absorb and they can be observed periapically in the roentgenogram.

In ***pituitary gigantism*** the teeth may be large, but not proportionately large, because morphodifferentiation, which determines the crown size, takes place long before the pituitary overactivity usually begins and always before the growth hormone has completed its effect on the

skeleton. In many cases of tooth gigantism the cause is unknown. One should differentiate gigantism of teeth from fusion and from gemination.

Partial anodontia is not uncommon, but complete anodontia is at least unusual, if not rare. Complete anodontia may be associated with ***ectodermal dysplasia.*** The latter is a disease of genetic origin characterized by dysplasia or aplasia of organs derived from the ectoderm. There may be absence of sweat glands, scant hair, faulty fingernail structure and malformation of the iris. In some cases, anodontia may be inherited without ectodermal dysplasia.

Hutchinson's teeth are a classic example of the effect of a systemic disease on tooth formation. They are caused by infection with *Treponema pallidum* during the morphodifferentiation stage of odontogenesis. ***Congenital syphilis*** is the causative disease. Hutchinson's incisors are slightly shorter than usual, are narrower at the incisal edge than at the cervical areas and have notched incisal edges.

Hypoplasia of enamel may be caused by any factor which interferes with the apposition of enamel. It should be understood that hypoplasia is a quantitative and not a qualitative defect. ***Endocrine deficiencies, lack of vitamin D or of calcium,*** and ***the exanthemas*** are the more generally recognized causes of hypoplasia of enamel.

SYSTEMIC DISEASES AFFECTING SKULL AND JAWS

Many of the systemic diseases which cause a disturbance of tooth development or tooth eruption do so through the medium of their effect on the jaws and skull. ***Rickets*** is one such disease. Infantile rickets may cause skull and jaw deformities and consequent irregularity of the teeth. Because victims of rickets do not properly utilize mineral salts because of the lack of vitamin D, there may result also hypoplasia of the teeth.

Gigantism will cause large jaws in children, but the tooth crowns will be normal in size, while the teeth will be widely spaced and the roots enlarged. The root enlargement may be due to hypercementosis.

In ***achondroplasia*** the cranial vault is large and the cranial base is underdeveloped. The victim of this disease has, in appearance, a saddle nose and a small face. Because the mandible is relatively normal, it appears to be in pronounced protrusion.

In ***leontiasis ossea*** there occurs an overgrowth of bone, localized in the face, and beginning usually in childhood. The etiology is unknown. The enlargement takes place in the maxilla, the malar bones, the supra-orbital ridges and occasionally in the mandible.

In ***microcephalus*** the face and teeth are normal in appearance, but the cranial contents are greatly reduced. The skull usually is very

small; the sutures close early. The patient's condition may be characterized by mental deficiency, paralysis, deafness and convulsions.

In ***oxycephalia*** the head has a high, conical crown known as "steeple head." The etiology is unknown, but the coronal and sagittal sutures close early. There occur maxillary retrusion, contracted maxillary arch, malocclusion, and delayed eruption of the maxillary teeth. The intelligence usually is normal.

Dwarfism caused by pituitary underactivity results in small but well proportioned individuals. Because the teeth differentiate earlier than the pituitary inadequacy, they are usually of normal size and are therefore crowded in the small jaws.

The ***mongoloid*** has a smaller head than is normal, scanty hair and a small mouth with large, protruding tongue and a delayed dentition. The cause of mongolism is not known.

Two very rare diseases of childhood are ***hemiatrophy*** and ***hemihypertrophy.*** They may occur in the fetus, at birth or in early childhood. They are developmental abnormalities involving one side of the body, including the head, the thorax, the abdomen, the extremities and all of the tissue components. The entire body may be involved, or only an extremity or the face.

When the face is involved in hemiatrophy, the development of the affected side is retarded. Atrophy occurs in the mandible, the maxilla, the zygomatic arch and the orbit. Even the tongue and the teeth may be decreased in size on one side.

In hemihypertrophy of the face, the teeth and jaws on the affected side are considerably larger than on the normal side. Development and eruption of the teeth on the affected side are accelerated.

DISEASES AFFECTING THE ORAL SOFT TISSUES

There are several systemic diseases which have symptoms in the oral cavity and particularly in the soft tissues. Some of these disorders present real danger for the patient, if his dental needs are not provided for under proper caution.

Addison's Disease. Children with Addison's disease must be managed with great care. Because of the increased deposits of melanin in the tissue, pigmentation of the lips, oral mucous membrane and gingiva is common. The pigmentation will range from bluish black to black. Because patients suffering from Addison's disease are very sensitive to minor stresses, subjection to extraction of teeth and to local anesthetics can prove very dangerous, even to the extent of causing death. Little danger exists if proper hormone therapy is employed. Cohen[1] lists the following precautions.

"1. Dental surgery should be postponed, if possible, until the patient's general condition has reached a satisfactory state. It should not be carried out in the presence of hypotension.

"2. Whenever possible, dental extractions should be performed with the patient hospitalized.

"3. A diet high in calories (3,000 or more) and carbohydrate (300 to 500 Gm.) should be ingested for at least one week prior to the operation.

"4. Vitamin C, 200 to 300 mg. daily, is given for one week prior to the operation.

"5. One cubic centimeter of lipo-adrenal cortex or 25 mg. of cortisone acetate is given by injection every eight hours for three days prior to operation.

"6. A single intramuscular injection of 12 mg. of vitamin K is administered on the day prior to the operation.

"7. On the morning of operation, a light breakfast is served, consisting of orange juice, cereal with sugar and cream, toast, jam and coffee. The patient is given 0.1 Gm. of Seconal with the breakfast.

"8. One-half hour before operation, 10 cc. of aqueous adrenal extract or 25 mg. of cortisone and 50,000 units of penicillin are given intramuscularly.

"9. A mixture of 20 per cent nitrous oxide and 80 per cent oxygen administered through a small nasal mask, leaving the mouth open for regulatory breathing and operating, is an excellent procedure for creating a state of analgesia in the patient, while fully conscious. The patient experiences no anxiety at all, and the local infiltration with Novocain and Adrenalin may be begun painlessly when the state of analgesia has been reached. Nitrous oxide is not to be used as the anesthetic agent but merely for the induction of analgesia."

Postoperative care should include a wholesome diet given at 3 to 4 hour intervals. Aqueous adrenal extract and 30,000 units of penicillin are given every 2 hours, day and night, for 48 hours.

Diabetes Mellitus. It has been estimated that there are approximately 50,000 known and 50,000 unknown cases of juvenile diabetics in the United States. Gingivitis, enlargement of the gingival papillae and calculus are common among juvenile diabetics. In those cases in which no control of the disease is obtained, there will be loss of bone, and frequent gingival and periodontal abscesses.

Leukemia. The leukemias will cause gingival enlargement in childhood. It is usually marginal, either of a local or a general nature. True leukemic enlargement is usually dull bluish red with an indented, shiny surface, irregular in form. There is a tendency to bleed profusely. The enlargement is due to engorgement of the blood stream

and submucosa by infiltration of the large number of white cells formed. The cells cause edema and a further enlargement of the gingival tissues. The gingival pockets which are formed harbor the oral organisms and, because of lowered tissue resistance, areas of necrosis may soon appear. The profuse bleeding of the gingivae may be the first sign of the disease. The oral signs may only suggest the presence of leukemia; they are not specific.

Hemophilia. In cases of hemophilia, there may be spontaneous bleeding from the gingivae. For this reason, extreme care must be taken by the dentist to prevent even minor trauma to the mucous membranes of the hemophiliac. Patients who require extraction of the teeth should be hospitalized. If more than one tooth needs to be extracted, it should be planned to perform all extractions at one operation. This will prevent the need for going through the same procedure on several occasions. Every hemophiliac should be under the care of an internist who will administer proper and adequate care preceding and following removal of the teeth. The important thing to remember is that minor operations can be extremely dangerous.

Hemophilia is a rare disease. However, hemorrhage following tooth extraction may be the first manifestation of the disease. It is, therefore, important to the dentist. The symptoms of this disease are not the same in all patients, but they do appear to be constant in a given individual. The first symptoms in childhood may be extensive subcutaneous hemorrhage following slight trauma. The disease may be first detected following the extraction or the exfoliation of a primary tooth. Bleeding frequently occurs concurrently with localized infection. For example, marked gingival bleeding may be associated with an abscessed tooth. Bleeding in hemophiliacs is typically an oozing and not a profuse flowing of blood.

Thrombocytopenic Purpura. A disease which may be confused with hemophilia is thrombocytopenic purpura. Bleeding and clotting values and the Rumpel-Leede test will permit a differential diagnosis. In essential thrombocytopenic purpura there are marked reduction in the number of blood platelets, increased bleeding time and failure of normal clot retraction. Before age 15, this is the most common form of purpura. Etiology is unknown, but it is thought to be related to some abnormal splenic activity. As in hemophilia, the first manifestation of the disease may be gingival bleeding. Nosebleed is also common in these cases. General treatment is, of course, the responsibility of the physician. A rapid increase in the platelet count follows splenectomy.

Epilepsy. The dentist should watch for signs of epilepsy in his patients. The excitement which is often present in the induction of nitrous oxide anesthesia predisposes to seizures. An epileptic, when rigidly re-

strained during a convulsion, may seriously injure himself. Epileptics do well with local anesthesia, if they are not fatigued and if they are properly premedicated.

If an epileptic patient does have a seizure while in the dental chair, he should be placed on the floor away from close proximity to walls or furniture in order to avoid serious injury.

The epileptic is of special interest to the dentist because of Dilantin gingival hyperplasia. One of the side effects of the use of Dilantin on the treatment of epilepsy is the marked gingival hyperplasia that may result. Why the hyperplasia develops is not known. This type of hyperplasia is seen primarily in children and young adults, and it has not been known to develop in edentulous areas.

It is uncommon for bleeding, inflammatory changes or secondary infections to occur in these cases. The tissue is firm and light pink, with a thickened, keratinized surface. In advanced cases, the teeth may be completely covered with gum tissue, showing a well defined line of demarcation between the normal gingiva and the hyperplastic tissue. When this happens, surgery is the best means of removing the proliferated tissue quickly and effectively. However, in order to prevent recurrence, it is important to attempt to gain the patient's cooperation in the institution of vigorous toothbrushing. It is well also to apply periodically superoxol to the interdental papillae to prevent the recurrence of tissue proliferation.

Tuberculosis. Tuberculosis in children may take on the form of either primary or secondary mouth ulcers. When pulmonary involvements are missing, the lesions will be primary and will involve the lip, the tongue, the gingiva or the tonsil. The induration will be sharply defined, will ulcerate and will cause lymph node involvement. Diagnosis is made by biopsy. Laboratory examination shows a granulomatous process and the presence of the tubercle bacillus in cases of tuberculosis with oral manifestations.

In children with pulmonary tuberculosis the secondary tuberculous ulcer is found more frequently. The ulcer may occur on the gingiva or tongue and the oral mucous membrane.

Syphilis. The effect of syphilis on the formation of the teeth has been described earlier. In addition, oral lesions are not uncommon in this disease. The primary chancre may be present on lip or tongue in a few cases; however, during the secondary stage of the disease the mouth may be extensively involved. The secondary stage is the metastatic stage of the disease. The buccal mucosa, the tongue and the pharyngeal wall will be involved with simple erosive or papulo-erosive lesions covered by a thin, silvery gray membrane. The amount of inflammatory reaction is slight.

The dentist should be on the alert for the mucocutaneous lesion of syphilis occurring at the angle of the mouth. It consists of a tiny papule which is moist and splits in one or more places. Such a papule may be the only demonstrable lesion of syphilis and is easily overlooked because of the common occurrence of fissures at the corners of the mouth.

The diagnosis of syphilis is made by demonstrating treponema of characteristic morphology in dark-field examination when the disease is in a stage at which those organisms can be demonstrated. In the late phases of the disease, syphilis is suspected on the basis of a positive serologic reaction.

Scurvy. The pathologic picture presented by clinical scurvy can be based on the reduction in the rate of formation of intercellular substances. Eventually there will be a complete failure to form those substances. In infants and children the characteristic signs of scurvy can be detected as pain on movement of the limbs, swelling of the extremities at the ends of the bones, angular enlargement at the costochrondral joints and a tendency to hemorrhage as shown by petechiae under the skin and hemorrhagic gums surrounding erupting or erupted teeth. The relationship of vitamin C deficiency to the gingival changes and to bone pathosis has been demonstrated frequently.

CONCLUSION

The dentist may be the first person to see oral evidence of systemic disease in a child patient. It might prove of inestimable value to the patient, if the dentist were able to diagnose the disease. Failing that, he should at least recognize that an unusual condition exists, and should at once see to it that the patient receives the benefit of further diagnostic services.

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Systemic Diseases of Interest to the Orthodontist

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The biologic aspects of orthodontics deal essentially with form and function. In consequence, illness which affects the development and dimension of facial structures, the metabolism of all tissues and the neurologic, muscular and osseous function is of importance in orthodontic case analysis, treatment and prognosis. Moreover, disease in which the metabolism of bone and muscle may be intimately related to the response of these tissues to mechanical stimulation concerns the orthodontist. The acute infections of relatively short duration, with occasional exceptions (acute bacterial endocarditis for example), do not produce enduring damage to the structures causing malocclusion. Therefore, excluding certain diseases of relatively infrequent incidence, the orthodontist is interested largely in secondary rather than primary effects of systemic disease.

The impact of both physiologic and pathologic entities upon the human face may be indicated diagrammatically by Figure 1. In this illustration the morphology of any face is the momentary result of the contribution of the physiologic forces of heredity, growth, development, and function acting through the structural mechanism of the face or, as some wish to express it, the facial complex.

These factors may, as they act reciprocally one upon another, possess the potentiality for harmony and balance or, if the fractions of one or all of these groups are deficient, facial asymmetry and malocclusion will prevail. For example, most students in orthodontics believe heredity to be the greatest etiologic contribution to malocclusion, acting as the genetic blueprint of the form of facial units and growth and developmental potentialities.

The physiologic elements not only interact but are in turn the recipients of impact from pathologic circumstances which may be grouped arbitrarily into the following classifications: malnutrition, disease and pressure, and trauma. Obviously, these headings are subject to endless subdivision. While our concern here by title definition is

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with disease, we cannot ignore the varied effects that identical disease entities have upon diverse hereditary, growth and development, and functional patterns. Likewise, disease may and often does affect nutrition, particularly if we broaden the term to include metabolism, and all are aware of the relation existing between disease, nutrition, and pressure habits of thumb and finger sucking. Perhaps I have made the first point in my thesis without further example, namely, that from the standpoint of the orthodontist disease can seldom be considered as a simple entity acting upon a single structure.

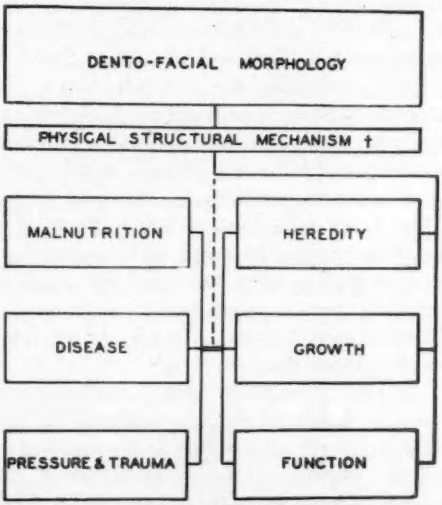

Fig. 1. Diagrammatic representation of physiologic and pathologic factors contributing to facial morphology.

At this point we should let the pendulum swing back and pick up some of the exceptions lost in the more general introductory observations. There are, of course, diseases which affect specific morphologic structures of interest to the orthodontist. Some are limited to the structures solely and others do or may have detrimental effect upon anatomic units of the face and jaws with secondary involvement of other tissues or unit systems of the body. The former is represented by the first mentioned below, and the latter is exemplified by the diseases of syphilis and hypoparathyroidism.

DENTAL CARIES

There is no need to dwell upon dental caries and the relation which it has to the etiology of malocclusion, or its contribution to complexi-

ties created in existing arch deformities. The surprising thing is the casual attitude which many orthodontists assume with respect to the disease itself and its relation to their problem. While the restoration of tooth substance that has been destroyed owing to carious processes is not the function of the specialist in orthodontics, the detection and prevention of these lesions in his patients is distinctly within his province. It has been my unhappy observation that many orthodontists having served several years in general practice become so engrossed in their specialty that they fail to recognize carious lesions until they have attained serious proportions.

ACROMEGALY

In hyperpituitarism occurring after puberty the cartilage of the condylar head responds to growth hormone and the mandible increases in size and extends downward and forward. This is one of several signs of acromegaly. In many cases, and for reasons less understood, there may be increase in size of the maxillae as well. The prognathism beyond the facial pattern of the individual presents an orthodontic problem that is characteristic and in high degree specific for the disease.

HYPOTHYROIDISM

In severe hypofunction of the thyroid gland in early ages there is a marked retardation of growth and, to a considerable extent, of development of the jaws as well. The condition is designated as cretinism. Fortunately, it does not occur commonly. More frequently, milder manifestations of hypothyroidism produce inhibition of jaw and particularly maxillary growth and retardation of eruption. There may be effects upon other growth centers as well, resulting in lack of full height; however, the extent to which this is a phenomenon associated with hypopituitarism is suggested but not completely confirmed. In patients who have a mild hypothyroidism which is sometimes difficult to demonstrate clinically, we occasionally see resorption of the roots of teeth, particularly maxillary incisors. In such individuals orthodontic treatment may accentuate this condition.

Perhaps it is not necessary to recite additional examples to indicate that there are certain disease entities which affect the structures of the face and units of special interest to the orthodontist. This is the second point of my thesis. Let us swing back again with the pendulum and consider diseases that secondarily affect the structure, growth and function of the teeth, jaws and adnexa.

CARDIAC INSUFFICIENCY

This may be due to a congenital lesion or damage from endocarditis. In either case there is scarcely a tissue that fails to show in some degree the effect of impaired circulation. These children are below their normal weight, their bones are delicate, their subcutaneous fat is diminished, and their musculature is poorly toned.

When defective function exists during the facial growth period the skeletal structure fails to attain its genetic potential. The growth cen-

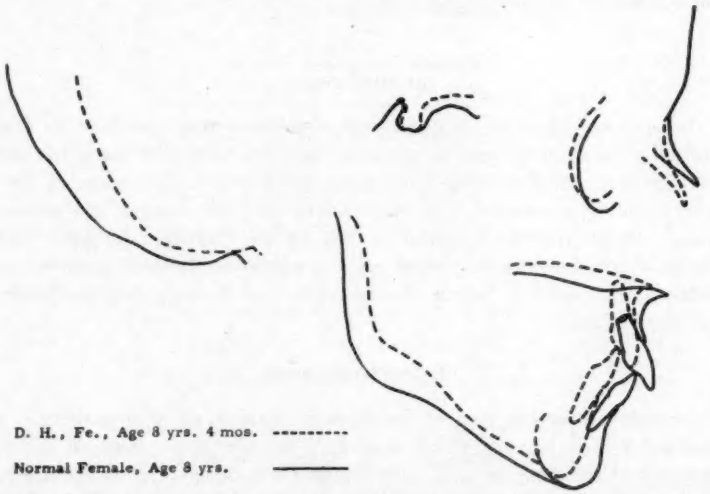

Fig. 2. Superimposed cephalometric tracings of a normal girl of 8 years (solid line), upon that of a girl (D. H.) age 8 years, 4 months (broken line), with a congenital heart lesion showing the retarded facial growth of the latter.

ters retarded are those that are active when the effects of the heart lesions are most acute.

A child so affected is a problem to the orthodontist, for his likelihood of reaching his full growth possibility is poor and response to mechanical pressures is slower than in the healthy child (Fig. 2).

ALLERGY

Here we may consider the typically allergic child, or one who approaches this clinical picture. He is often a feeding problem in infancy and has diaper rashes and skin lesions in early childhood. Epistaxis is common, as is respiratory irritation with cough not related to infectious disease. Allergy jumps from one allergen to another. These

youngsters may react to anything from house dust to the print upon comic strips. After suffering from typical hay fever and asthma some may enjoy comparative or complete freedom from their earlier distress when they enter their twenties, but the interval of retarded growth is never fully compensated.

Allergic children are usually slender and irritable because of lack of energy reserve. Their muscles are poorly toned, which is evident in grasping the hand in handshake, or in palpation of the forearm or thigh. They are apprehensive in the dental chair, jumpy and squirming through examination, grab for instruments and have a generally bratty behavior. If the orthodontist realizes he is dealing with a sick child and keeps his temper and composure, knowing he is confronted with a problem in patient management, he may win the confidence of the child and through consultation with parents guide them to allergy control through intelligent and effective medical assistance. Appraisement of the systemic condition of the allergic child is essential in determining the time for initiation of orthodontic treatment. When the practitioner recognizes this systemic disease he may accept the challenge and try to play this course of treatment in par. If he falls to the child's level and in turn is cross and irritable, he is doomed to failure.

A child such as I have described responds poorly to orthodontic treatment when his allergy is active. While bone change essential to tooth movement is possible, the period of retention is prolonged, the hazard of relapse is heightened and the assistance of normal and vigorous function in building a harmonious dentition is greatly diminished.

CONSTITUTIONAL INFERIORITY

There are certain children who, though not stricken with any specific disease entity, present the distinct appearance of ill health, and for want of a better term have sometimes been designated as constitutionally inferior. These youngsters are underweight, pale, and frequently have a worried or apprehensive expression. There is evidence of over-all lack of facial growth. The maxilla is posterior to the position we would expect in the facial pattern of a normal child. The mandible is short in ramus height and in consequence is retrognatic. The antigonial notch is usually accentuated. Moreover, the alveolar bone is osteoporotic and the arches are narrow. The malocclusion is usually class I with lack in arch length, or class II division 1.

The problems in treatment are similar to those enumerated in the sections dealing with the allergic child and cardiac deficiency. There is on occasion considerable improvement in the systemic condition just before and during puberty, particularly in girls, but this does not

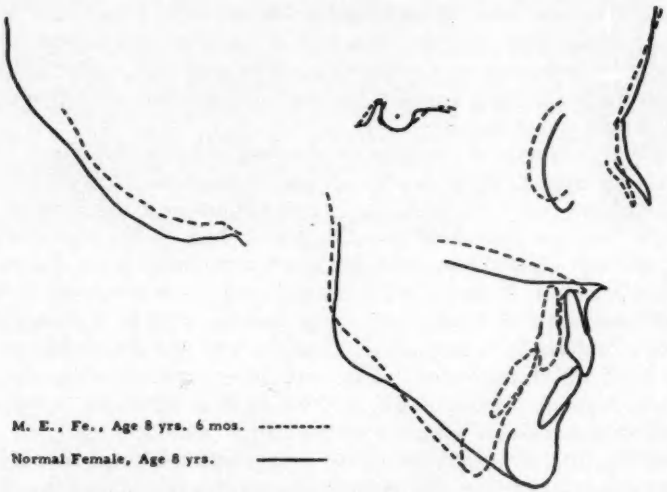

Fig. 3. Superimposed cephalometric tracing of a normal girl, age 8 years (solid line), upon that of a constitutionally inferior girl (M. E.) age 8 years, 6 months (broken line), showing lack of facial growth.

compensate for the handicap previously sustained. In cases of this sort the orthodontist may be committed to compromise. He will be assisted by parents and pediatrician in maintaining a good nutritional and hygienic level and particularly in keeping the child's energy expenditure within the limits of the energy reserve (Fig. 3).

* * * * *

The reader will note that in making the third point of this discussion I have avoided a recitation of pathologic entities which are treated in general and oral pathology texts. A particularly good reference is Lester W. Burket's *Oral Medicine*. It is obvious that space does not permit an encyclopedic enumeration of systemic disease in which the orthodontist may have interest or concern; hyperparathyroidism, cleidocranial dysostosis, neurologic disturbances (the spastic child, and poliomyelitis) are but a few examples.

It has been my purpose to indicate certain diseases that affect the facial structure specifically, and other conditions that interfere with facial growth and developmental progress. The latter concern the orthodontist, not alone because of the structural deficiency but as well through impaired metabolic function which prevents a normal response to mechanical stimulation and physiologic function. I have

indicated the need for medical and nutritional consultation as well as cooperation in the home.

Diseases which create deformities of the structures of the face are essentially of academic interest to the orthodontist for they are in large measure inactive when he first sees his patient. The disease has struck and left a condition with which the orthodontist must deal. His treatment is related to the morphology he encounters and the health and biologic reaction of the child, not the pathology of the entity which caused the deformity.

There are, however, conditions which affect growth, development and function within the face to which I have alluded in this discussion. These have important bearing upon the nature of the treatment, the time of its institution and the prediction of result.

In closing I should like to quote from conclusions of a paper I presented on a similar subject before the American Society of Orthodontists in 1937, "Clinical Orthodontic Evidence of Systemic Disease," (Am. J. Orthodont. & Oral Surg., 24:27, 1938):

"1. Accurate diagnosis and skillful mechanics do not completely solve the orthodont's problems.

"2. The face is one of the most sensitive areas of the human body to systemic disturbance.

"3. Because of the delicate balance required between growth, development and function, subclinical disturbances may be most evident through their effect on facial development.

"4. Facial deformities and malocclusion may often be the means of discovering general systemic disturbances, but it should be remembered that these local conditions seldom name the exact cause. They indicate a deviation from normal progress; its etiology must be sought elsewhere.

"5. A knowledge of the systemic background of the child and appraisement of his general as well as facial growth and developmental progress will be found to be of assistance in diagnosis, treatment and prognosis."

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Problems in Growth and Development of Interest to the Dentist

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In recent years the "whole child" concept has become a focus of emphasis in medicine, in psychology, and in dentistry. Strictly speaking, the consideration of this concept has far too often been in the realm of lip service. The fact that it is considered at all is its major achievement. Yet, it is an important concept for it means that one considers not an item—a broken bone, a single behavioral trait, a carious tooth—but an entire bio-behavioral complex, a psychosomatic whole. Nowhere is this all-for-one-and-one-for-all approach more pertinent than in the area of growth and development, and no less in the dental than in the medical field. It is not a single tooth that calcifies and erupts: it is a tooth related to an adjacent tooth, to an arch configuration, to an arch-to-arch reciprocation, to an arch-facial complex, to a facio-cephalic balance, and so on—and *all* related to the entire organic growth process with all of its endogenous and exogenous stability and/or variability. Growth and development is a "package deal," a very complex and highly integrated affair. It is something the dental profession can work with.

BASIC DEFINITIONS

The term "physical growth" is an embracive one: it is the sum of all morphologic and physiologic changes in the organism from conception until death; it involves an orderly progression of embryonic differentiation, fetal and postnatal growth, per se, and later postnatal age-changes. Within this over-all picture we may speak of "development," which involves an increasing organic complexity as functional integration proceeds; the complex of changes at puberty is a good

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example. Again, we may speak of "maturation," which is the progressive and cumulative ageing of organs and tissues; maturity is a goal (sexual maturity, or adult maturity, organically speaking), but maturation is the process, the rate of march toward the goal.

At the risk of oversimplification we might summarize physical growth in a threefold manner: *we grow; we grow up; we grow older.* Or, we get bigger, we change proportions, we mature. The whole process is a beautifully ordered one: there is regularity; there is integration; there is acceptable and predictable variability. All this can be quantified and objectified—it can be measured and it can be standardized.

BASIC CONSIDERATIONS

Part of the growth process is fixed—it is genetic; part is modifiable—it is subject to environmental variables. Which is which? This is an age-old question, and answers are still not hard-and-fast. A look at the accompanying analytic schema will serve to tell why.

The Bases of Growth

CELLULAR ↔	ORGANIZATIONAL ↔	ENVIRONMENTAL
↓	↓	↓
The gene complex expressed as family-line heredity	Axis and gradient Time and sequence Form and proportion	Physico-chemical balance and cellular efficiency
↑	↓	
(There is stability here)	Biogenetic potential	Metabolic and endocrinic levels
	↑	Health, nutrition
	(There is limited variability here, probably genetically controlled)	
		Traumata (incl. habits)
		Misc. factors (season, climate, etc.)
		↓
		Individual growth pattern
		↓
		Adult size and form
		↑
		(There is great variability here)

This trichotomy implies a distinctness which in fact does not really exist. I have tried to show this by the two-way arrows between each column heading. In a sense, column one is our endowment, column two our embryonic and fetal life, column three our postnatal life. Beyond that we shall not elaborate, save to point out that the entire process is amenable to a reasonably acceptable age-period classification, as follows:

Prenatal

1. Embryonic, *ca.* first three lunar months.
2. Fetal, *ca.* last seven lunar months.

Postnatal

PERIOD	BOYS	GIRLS
1. Infancy	Birth—1:0	Birth—1:0
Newborn	1st two weeks	1st two weeks
Infancy, per se	Up to 1:0	Up to 1:0
2. Childhood	1:0–16:0	1:0–15:0
Early	1:0–6:0	1:0–6:0
Mid	6:0 to 9:0–10:0	6:0 to 9:0–10:0
Late	9:0–10:0 to 13:0–16:0	9:0–10:0 to 12:0–15:0
3. Puberty	*ca.* 13:0–14:0	*ca.* 12:0–13:0
4. Adolescence	13:0–14:0 to 18:0–20:0	12:0–13:0 to 18:0–20:0
5. Adulthood	18:0–20:0 plus	18:0–20:0 plus

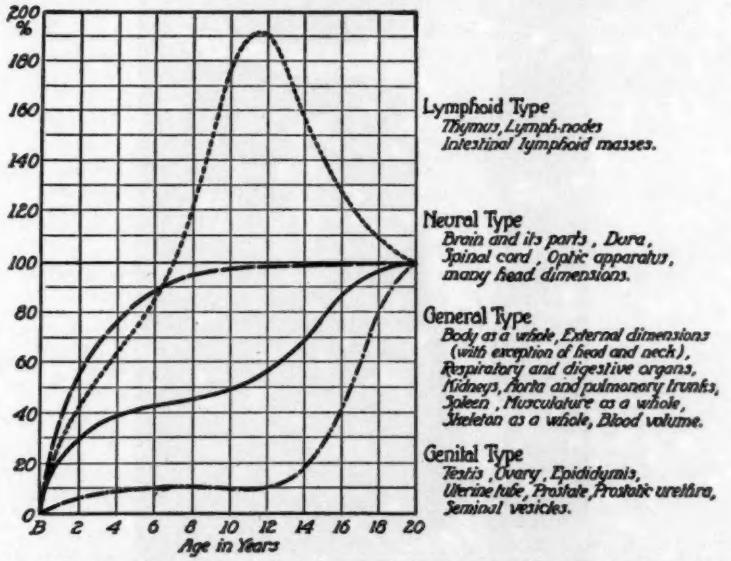

Fig. 1. The four basic types or curves of postnatal physical growth in the child. (From Scammon, reference 15.)

Within this framework—which is only an approximation or "average"—we will work. Our discussion will center upon the first two decades of postnatal life, the human growth period par excellence.

A first over-all look at these two critical decades tells us that time and sequence unite to give a picture of remarkable order. There are "patterns" of postnatal growth which permit a logical grouping by organ systems. These are the four major types of growth curves as outlined by Scammon:[15] the N or neural curve, the G or general curve,* the L or lymphoid curve, and the Ge or genital curve (see Fig. 1).

* I prefer to call this the B curve, for bone (skeletal), brawn (muscular), blood (vascular), breathing (respiratory), bowel (digestive), and bladder (urinary part of the urinogenital system).

In these curves the adult value, at age 20 years, is taken as 100 per cent of the growth potential; birth is at zero; progress toward adult status is expressed as a percentage achievement, at any given age.

Of major interest to us in the present discussion is the contrast between the N and G curves. The N curve shows cranial vault and orbit to grow with amazing rapidity—they are, for practical purposes,

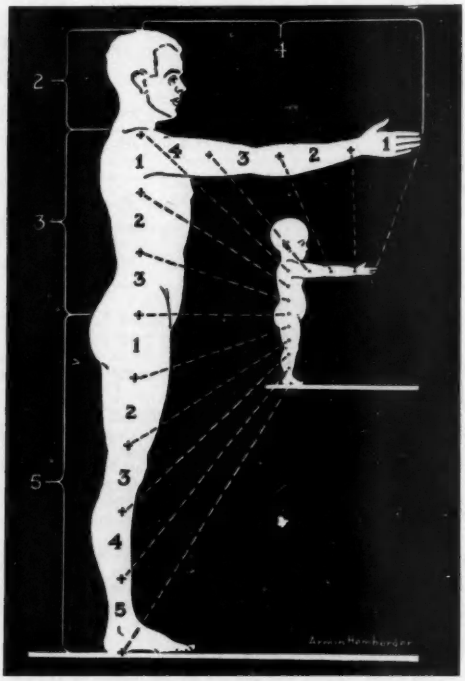

Fig. 2. Schematic proportional changes in postnatal growth from birth to adult. (From Goff et al., reference 4.)

adult at about 6 years or so. On the other hand the G curve demonstrates that the skeleton generally grows at a much slower rate: there is acceleration, deceleration, acceleration, and terminal deceleration spread out over 20 years. This means a startling disparity in growth tempo between skull and face, and between upper moiety of face (N curve) and mid and lower moieties of face (G curve). This is an inherent timing factor to be reckoned with, for it is vitally involved in problems of cephalo-facial and in upper-lower facial proportions.

The whole problem of proportional growth in the body generally is highlighted by Figure 2 (from Goff, et al.[4]). In very broad terms,

during postnatal growth head and neck increase twofold, trunk threefold, arm fourfold, and leg fivefold. This is how we *grow* and this is how we *grow up*.

It is now time to extend our age category, already given, into a more meaningful area. The timing of infancy, childhood, etc., has been given in terms of chrono'logic age (C.A.). In a sense this has meaning only in a cultural context, for the calendar is man-made. A child born on 12-1-47 and seen on '2-1-57 is 10 years of age. But, is this his *real* age—and what do I mean by "real age"? To answer this we must return to the concept of maturation (we *grow older*), which is a biologic concept and, hence, reflective of individual growth tempo. The biologic age, not the chronologic age, is the child's "real" growth age.

A biologic age of special interest to dentists is *dental age* (D.A.). This is based on tooth eruption as seen in the following, which is a modification* of Hellman's original scheme:

Stage II. Period of Late Infancy

A. All deciduous second molars erupting or erupted, including 50% eruption of all of them or 75% of three of them.

V IV III II I I II III IV V
V IV III II I I II III IV V

C. Beginning of eruption of first permanent molars, including elimination of deciduous incisors and eruption of their permanent successors.

V IV III 1 1 III IV V
6 V IV III 2 1 1 2 III IV V 6

Stage III. Period of Childhood

A. All first permanent molars erupting or erupted, including 50% eruption of all of them or 75% of three of them.

6 V IV III 2 1 1 2 III IV V 6
6 V IV III 2 1 1 2 III IV V 6

B. Elimination of deciduous canines and molars, and acquisition of their successors.

6 5 4 3 2 1 1 2 3 4 5 6
6 5 4 3 2 1 1 2 3 4 5 6

C. Beginning of eruption of second permanent molars.

6 5 4 3 2 1 1 2 3 4 5 6
7 6 5 4 3 2 1 1 2 3 4 5 6 7

Stage IV. Period of Circum-pubescence

A. All permanent second molars erupting or erupted, including 50% eruption of all of them or 75% of three of them.

7 6 5 4 3 2 1 1 2 3 4 5 6 7
7 6 5 4 3 2 1 1 2 3 4 5 6 7

C. Beginning of eruption of third permanent molars.

7 6 5 4 3 2 1 1 2 3 4 5 6 7
8 7 6 5 4 3 2 1 1 2 3 4 5 6 7 8

Stage V. Period of Post-pubescence ("Adolescence") to Maturity

A. Complete eruption of all third permanent molars.

8 7 6 5 4 3 2 1 1 2 3 4 5 6 7 8
8 7 6 5 4 3 2 1 1 2 3 4 5 6 7 8

* Philadelphia *Growth Center*.

The concept of "dental age" has only limited use in human growth studies, but is very useful for comparative purposes, i.e., equating eruptive sequence and growth timing in non-human compared to human. In human material its great variability makes it applicable only within a wide age-range, as seen in Table 1 (where H = Hellman, G.C. = *Growth Center*).

These data are for white children. We have reason to believe that different schedules should be drawn up for Negro children and for Chinese children. In cases of severe endocrine dysplasia, D.A. adheres far more closely to C.A. than to another basic measure of biologic age, termed skeletal age (S.A.).

TABLE 1. *Dental Age Data for White Children*

	MALE			FEMALE		
STAGE	RANGE	AV.	S.D.	RANGE	AV.	S.D.
II A (H)	—	5.33	0.94	—	5.36	1.08
II C (H)	—	6.67	0.60	—	6.63	0.69
III A (G.C.)	8–11 yrs.	8.74	1.03	8–12 yrs.	8.67	0.88
III B (G.C.)	8–13 "	10.19	1.35	8–13 "	10.04	1.24
III C (G.C.)	10–13 "	11.68	0.91	10–13 "	11.64	0.89
IV A (G.C.)	12–14 "	12.64	0.59	11–13 "	12.50	0.66
IV C (H)	—	20.69	2.01	—	20.35	1.85
V A (H)	—	23.02	2.41	—	21.10	2.18

It is this biologic age, the registration of growth tempo in the growing and maturing skeleton, that is the best single evaluation of human growth and development. It is based on the assessment of x-ray films of the left hand using either the Todd[17] or the Greulich and Pyle[5] standards. In Figure 3 are seen the centers of ossification in the hand (distal radius and ulna, carpals, metacarpals, phalanges), each with its own set of "maturity indicators."

The value of S.A. resides in the fact that the child grows in accordance with this tempo rather than that of C.A. There are "early," "mid" and "late" *maturers* which are definitely and positively correlated with "fast," "average" and "slow" *growers*. This means that early maturers grow faster, i.e., are taller and heavier age-for-age, and so on. Moreover, as we shall see later, early maturers tend to have an accelerated facio-dental growth complex.

HOW CAN GROWTH DATA BE USED?

In a sense I might first give a theoretic answer: we use growth data to analyze and interpret the integrative nature of growing, growing up, growing older. However, more practical and more immediately applicable reasons are somewhat as follows:

1. We study growth to evaluate the growth status of the child. The word "status" is the key here, for it implies an answer to the question, "Has this child, at this age when first seen, grown acceptably?" In other words, we must have techniques to appraise acceptability vs. non-acceptability as an initial or first evaluation. Here is an example: At first examination John is eight years old (C.A.); what is his height

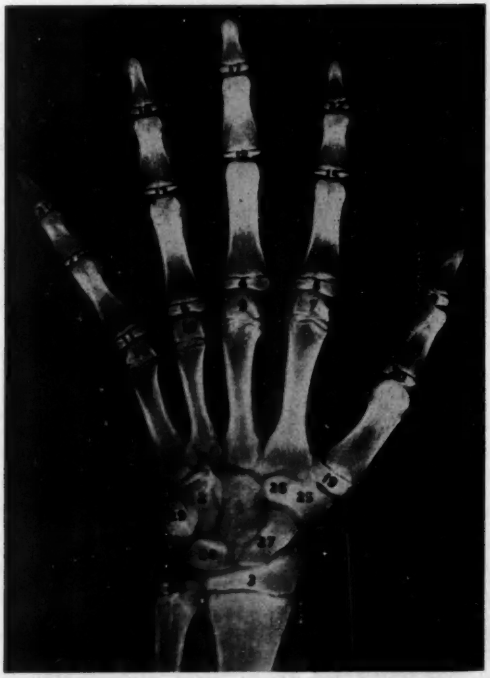

Fig. 3. X-ray film of hand of adolescent boy showing sequence of appearance of centers of ossification. (From Greulich and Pyle, reference 5.)

age? his weight age? his D.A.? his S.A.? is he an early maturer? a fast grower? in toto where does he fit in the growth picture?

2. We study growth to assess the growth progress of the child. Here "progress" is the key word; to paraphrase a well known advertising slogan, "Progress is the most important product of growth." The concept of progress is basic to growth research and to the understanding of the unfolding growth pattern. It means that we no longer use cross-sectional data (one average at birth, one at one year, one at two years, and so on); we employ longitudinal or serial data, based on a single

sample of children followed from year-to-year (or semiannually or quarterly). This follow-up method permits of a very important interpretation, that of "incremental growth," or the amount of growth expected between any two periods of time (either C.A., D.A., or S.A.). Incremental growth, in turn, permits of two important interpretations: (1) it is possible to assess rate or "velocity" of growth; (2) it permits of a measure of prediction in terms of expected amounts of growth. Incremental growth can be used to give an idea either of *absolute* growth or of *relative* growth.*

3. We study growth to provide some sort of framework of comparability. Here we come to grips with reality. Here is focused the problem of "norms" or "standards." Is the child "normal"? Normal with reference to what? to height? to weight? to tooth eruption? to maturation? and with reference to C.A.? to D.A.? to S.A.? This means that we *do* have tables of average height, weight, tooth eruption, and so on; it means that these reference data will help interpret the child's growth status and progress—but always in terms of how the child compares to all other age-peers and sex-peers. All this is useful, of course, but comparability is only relative, not absolute—it is only an approximation of *where*, in the total distribution, the child finds its growth-place.

4. We study growth to give us a clearer picture of the possible hereditary transmission of physical characteristics. In its simplest expression we ask the question, "What has the child inherited from the mother, what from the father?" i.e., what from the maternal "family-line," what from the paternal? There is reason to believe, as we shall see later, that there are unit traits in teeth, jaws, and face that may be inherited independently or in genetically linked complexes. In the serial growth studies of children we may follow and observe the working-out of the "biogenetic pattern" of growth; also, we work with siblings, parents, grandparents, and parental and grandparental generations.

5. Finally, we study growth to grant *individuality* to the child. Status, progress, comparability, and family-line background, all combine to confer upon the child a measure of uniqueness. This must be kept in mind when "norms" or "standards" are used to judge the child's growth position. This is the real basis of the *whole child* concept. Mass data studies, with their averages, their normal range of variation, serve mainly to orient our thinking, so that the child, as a clinical entity, can be fitted somewhere (not precisely) into the overall picture.

* Let us say, for example, that bizygomatic width increases from 100 mm. to 108 mm. in a single year. The *absolute* growth is 8 mm. (108 mm. – 100 mm.). The relative growth is 8 per cent (8 mm./100 mm.).

THE USE OF HEIGHT-WEIGHT GROWTH

These two measures of growth are generally accepted as the best single indicators of healthy, normal growth progress. The acceptance is based largely on the universality of available information: in every country, for every age, height and weight are routinely recorded in medical records, school examinations, public health clinics, and so on. We know more about height-weight growth than of any other single dimension: there are height-age tables, weight-age tables, and weight-for-height tables. Strictly speaking, these tables should be drawn up for each sex, and for each race, and should take cognizance of body build (the so-called "constitutional" factor) and of family-line differences (the hereditary or genetic factor).

There are many height-weight devices, ranging from simple tabulation of mean values (based on C.A.) to more elaborate schemes of percentile ranking and of graphic presentation (also, all based on C.A.). One of the more widely used examples of the latter is the Wetzel Grid,[18] shown in Figure 4. In this figure height and weight data are tabulated and plotted for a boy seen 14 times between ages 6:0 (6 years) and 13:8 (13 years, 8 months).

The left side of the Grid plots weight against height; this will give a height-weight expression of form or build, as depicted in the "physique channel." These channels give an M path, and A_{1-4} paths (A for *a*bove), which are progressively heavier or stockier, and B_{1-4} paths (B for *b*elow), which are progressively lighter or more slender. A_1, M, B_1 are clinically rated as "good," A_{2-3} as "stocky," A_4 and above as "obese," B_2 as "fair," B_3 as "borderline," and B_4 and below as "poor." Growth progress in height and weight tends to be channel-wise or channel-to-adjacent-channel. In addition, incremental growth is recorded via "isodevelopmental levels" (recorded as dev. level = developmental level in the tabulation). The rule or accepted progress is one dev. level per month, or "10-per-year."

The right side of the Grid relates the child's growth (H-W) progress to that of all other children on a C.A. basis. Here the 67th percentile is the standard; children to the left of the 67 per cent are "advanced" (15 per cent, 2 per cent), those to the right are "retarded" (85 per cent, 98 per cent).

In the example given in Figure 4, the boy is doing reasonably well: he runs along an A_1-M path; in 6:8 years (between 6:0 and 12:8) he has achieved 71 dev. level units (from 49 to 120); he has advanced all along in the H-W growth, compared to the 67 per cent standard, i.e., he is near the 85 per cent, or in the 15 largest boys per 100.

Now, what is the real importance of H-W data? The answer is simply this: it is *timing*—when, in the growth-life of the child, there is

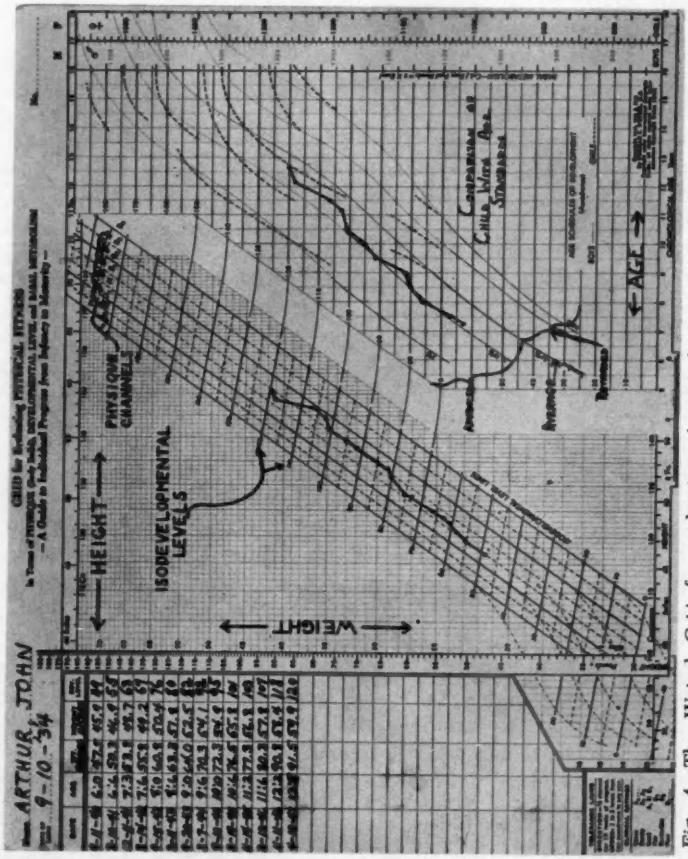

Fig. 4. The Wetzel Grid for evaluating physical fitness, showing salient characteristics and a single case history. (See Wetzel, reference 18.)

the most marked H-W acceleration. We know there is a marked acceleration at a very early age—birth length increases by 50 per cent in the first year of life—but the really important acceleration (applicable to the field of dentistry) is that of the pre- and circum-pubertal growth phase, at any time between, roughly, 10 and 15 years of age. Why? Because the timing of the height "spurt" in growth (which is governed by S.A. rather than C.A.) is positively related to the timing of incremental growth in the facial skeleton. Let us say, for example, that a boy begins his pre-pubertal statural acceleration (as measured by both absolute and relative incremental or velocity growth) at about 12:3; this means that for about 2 years (his whole circum-pubertal acceleration) he is going to be in a phase of rapid height growth. More than that, however, it means a period of incremental growth in facial dimensions—with the exception that the timing is a bit different, i.e., the growth spurts in facial dimensions do not begin for 9 months or a year *after* the initiation of the more generalized height spurt. In the example given, if 12:3 is the trigger date for height increase, 13:0–13:3 would be the trigger period for facial increase. Later, we shall focus upon the facial dimensions most involved.

FACIO-DENTAL GROWTH

We have already noted that the facial skeleton grows in obedience to two "types" of growth impulse, neural (upper face) and general or bodily (mid and lower face, including the mandible). We have noted, further, that mid and lower face are time-linked, but not directly synchronous, with the growth of the long bones of the infracephalic skeleton.

One of the most obvious problems in facio-dental growth is that of the eruption of the teeth. The best available data for the deciduous teeth are those by Meredith,[11] and for the permanent teeth those by Hurme.[6] They are given in Tables 2 and 3, respectively.

There are several ways in which the growth of the facial bones may be studied and/or measured, either via the experimental method on non-human primates and mammals or by measurements on human skulls, the human head, or x-ray films of the human head. We speak of measurement of the skull as *craniometry*, measurement of the head as *cephalometry*, and measurement of the x-ray film as *roentgenographic cephalometry*. In general, following Sarnat and Gans,[12] there are two major approaches, direct and indirect. They are evaluated as indicated in Table 4.

Vital staining and implants have revealed that growth in the face occurs in two ways: sutural and appositional-resorptional, the former

TABLE 2. *Deciduous Tooth Eruption in Months and Years*

ORDER	AVERAGE ERUPTION 7½ MONTHS	1 YEAR	2 YEARS	3 YEARS
Lower central incisor	+	+	+	+
Upper central incisor		+	+	+
Upper lateral incisor		+	+	+
Lower lateral incisor			+	+
Upper, lower first molar			+	+
Canine			+	+
Lower second molar				+
Upper second molar				+
	2	6	16	20

From Meredith, reference 11.

TABLE 3. *Permanent Tooth Eruption in Years*

	MALE EARLY	MALE AVERAGE	MALE LATE	FEMALE EARLY	FEMALE AVERAGE	FEMALE LATE*
Maxillary Teeth						
Central incisor	6.67	7.47	8.25	6.38	7.20	8.00
Lateral incisor	7.67	8.67	9.67	7.21	8.20	9.17
Canine	10.33	11.69	13.08	9.63	10.98	12.33
First premolar	8.92	10.40	11.88	8.58	10.03	11.50
Second premolar	9.63	11.18	12.75	9.33	10.88	12.46
First molar	5.58	6.40	7.21	5.42	6.22	7.00
Second molar	11.33	12.68	14.04	10.92	12.27	13.63
Mandibular Teeth						
Central incisor	5.75	6.54	7.33	5.50	6.26	7.04
Lateral incisor	6.83	7.70	8.58	6.46	7.34	8.21
Canine	9.50	10.79	12.08	8.58	9.86	11.13
First premolar	9.33	10.82	12.29	8.71	10.18	11.67
Second premolar	9.79	11.47	13.17	9.21	10.89	12.58
First molar	5.42	6.21	7.00	5.13	5.94	6.75
Second molar	10.75	12.12	13.50	10.29	11.66	13.00

From Hurme, reference 6.
* Early, Average, Late are mean ± one standard deviation.

TABLE 4. *Methods of Measuring Growth of Facial Bones*

	LOCUS	AMOUNT	TIME AND RATE	DIRECTION
	Direct Methods			
Craniometry	no	yes	yes	inferential
Cephalometry	no	yes	yes	inferential
Vital stain	excell.	excell.	good	yes
Implants	good	excell.	good	yes
	Indirect Methods			
Casts, photos	no	yes	yes	possible
Roentgenographic cephalometry	no	excell.	good	good
Roentgenographic cephalometry, plus implant	excell.	excell.	excell.	excell.
Bone-end marker	good	good	good	good

leading mainly to dimensional increase, the latter mainly to remodeling, i.e., change in form. In the child, cephalometry and roentgenographic cephalometry both permit of serial or follow-up growth analysis.

In Figures 5 and 6 is shown the scheme of measurements of the

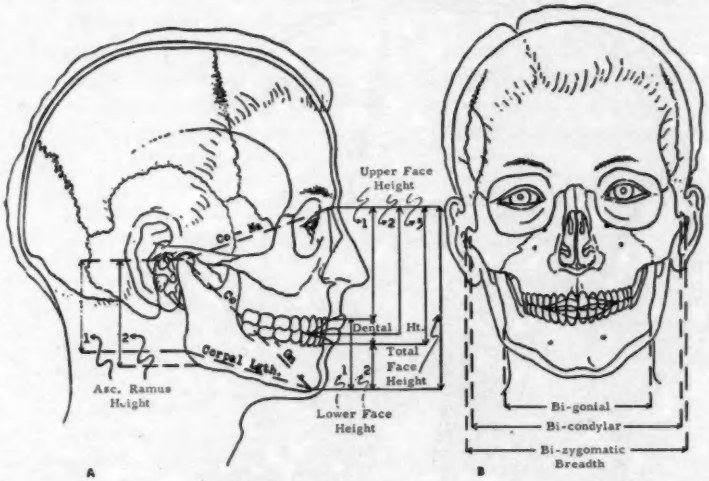

Fig. 5. Cephalometric height dimensions (*A*) and breadth dimensions (*B*) taken on the living head. (From Krogman, reference 9.)

living face, made serially. They are logically divided into three groups: heights, breadths, and depths (or vertical, transverse, and sagittal or mesiodistal). We are not here going to present detailed dimensional tabulations, but shall offer an over-all cephalometric appraisal. If we summarize the three groups in their postnatal growth (taking adult values as 100 per cent) then the picture is as follows:

GROUP	PERCENTAGE OF GROWTH ATTAINED AT BIRTH	PERCENTAGE OF GROWTH ACHIEVED POSTNATALLY
Breadths	55–60%	40–45%
Heights	40–45	55–60
Depths	30–35	65–70

These data emphasize the differential and proportional nature of postnatal facial growth in that prenatally the growth-order (size) is breadth, height, depth, while postnatally the order is reversed. Of major importance is the fact that the mesiodistal dimensions (the "forward" growth of the face) have the longest growth road to traverse, as it were. It is not the amount, per se, that is so important, it is the fact that the greater the amount of growth to be achieved the greater the vulnerability, i.e., the more chance of dysplastic or deviant growth.

It is no accident that most "growth failures" in the face are related more to depth-positional deviations (mid-face to cranial base, mandible to maxilla) than to any other complex.

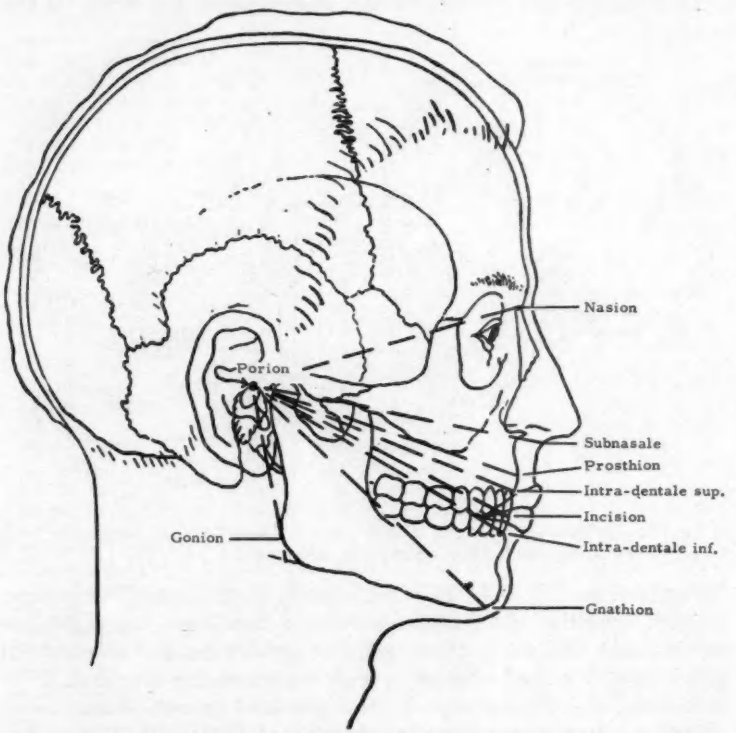

Fig. 6. Cephalometric depth dimensions taken on the living head. (From Krogman, reference 9.)

There is another way of looking at the growth in the three great groups of dimensions. Related to tooth-eruption the sequence and inter-relationship is somewhat as follows:

TIME	DEPTH	BREADTH	HEIGHT
1. From birth to 3 yrs., (for decid. dentition)	Greatest increase	Moderate increase	Slight increase
2. Up to 6 yrs. (for M1, I1-2)	Moderate →	Moderate →	Moderate
	(all mod., in order D, B, H)		
3. Up to 9–10 yrs. (completion I1-2, eruption Pm1-2)	Slight to moderate	Moderate ↔ (B and H equal)	Moderate
4. Up to *ca.* 12 yrs. (eruption C, M2)	Greatest increase	Moderate ↔ (B and H equal)	Moderate
5. Up to *ca.* 18 yrs. (eruption M3)	Moderate	Slight to moderate ← (H greater than B)	Moderate to slight

As is true of all schema the above is oversimplified and it probably gives a spurious definitiveness, i.e., the pattern is not really as rigid as it seems. However, the outline is a good one from which to observe the individual, and *individual variation* within the over-all picture. It is not too far wrong to say that children's faces will grow "about this way," though not in precise detail.

Roentgenographic cephalometry is the answer to the problem of precision and of detail. The technique, brought to fruition by Broadbent,[2] employs cephalo-facial roentgenograms taken serially under standardized conditions in two views, left lateral and postero-anterior.

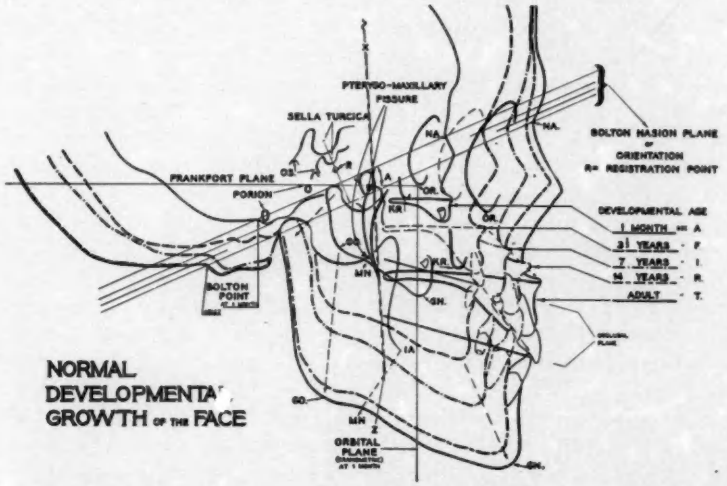

Fig. 7. Normal developmental growth of the face from one month of age to adult. (From Broadbent, reference 3.)

The resulting sets of films are then carefully traced, and via superimposition, are compared, age-to-age (film two placed on film one, three on two, four or three, and so on).

A classic picture of facial growth has emerged via this technique. It is shown in Figure 7 (Broadbent, 1941), depicting over-all growth from one month of age to adult.

The lateral roentgenogram has received by far the most intensive study. Resultant tracings have been submitted to many different kinds of "analyses," which have been summarized by Krogman and Sassouni.[10] Recently, Sassouni[13,14] has offered a proportional analysis, designed for interpretation of the individual facio-dental complex, which employs both lateral and p-a films.

From the experimental animal to man, from craniometry to cephalometry to roentgenographic cephalometry, the progress has been sure and increasingly informative. Our knowledge of facial growth and its relation to the teeth is on pretty sure grounds. Application of that knowledge to specific clinical cases is not as clearly understood or interpreted; yet the march is on, for researcher and clinician are ever more closely joining hands.

HEREDITY IN FACE AND TEETH

What is inherited? A whole face? A whole dentition? Or is bone independent of tooth? Or tooth of tooth? What we are asking is this: is there pattern or complex heredity? or is there unit or trait heredity? In practical terms are there some paternal traits, some maternal traits, more or less randomly inherited—for example, paternal dentition, maternal facial bones (especially mandibulo-maxillary)? Answers are not clear-cut, by a long shot! However, evidence is mounting that unit-trait inheritance, rather than an entire complex or pattern, is the rule. Stockard's[16] work with dogs was a major step in this direction.

Recently Kraus[7] has described a number of heritable traits in the human dentition: (1) *developmental,* as age at eruption and sequence of eruption of deciduous and permanent teeth; calcification of crown; and time of coalescence of molar cusps; (2) *mensurational,* as crown dimensions and root lengths, number of cusps and roots, dentin-enamel ratio of crown surfaces, and relative size of molars; (3) *morphological,* including crown pattern and pits, ridges, grooves, and fissures; cuspules; bent and fused roots; Carabelli's cusps; shovel-shaped incisors; enamel extensions and nodules; taurodontism; and crown shape; (4) *anomalous,* as supernumerary teeth and roots, "congenitally" missing teeth, peg teeth, and paramolar tubercle of Bolk; (5) *topical,* as diastemata, trema, bite and jut, prodontism, shape of dental arches, and incisor rotation.

Asbell[1] contributes a more general study of dental occlusion, employing the "family-line" method of analysis. There are three ways of heritable transmission: (1) repetitive trait, (2) discontinuous or assortative trait, (3) mixed traits. Involved in this study are class and sub-types of malocclusion, types of cross-bite and open-bite, and missing and supernumerary teeth (both unilaterally and bilaterally considered). The study is largely in the period of the mixed dentition.

The use of all this information is, as yet, rather limited. Just as there is uncertainty in the precise definition of genotype, so there is uncertainty in its application. The best rule to offer is one of pragmatism: look at each parent carefully, look at siblings, then come to an ap-

praisal of "which side of the family the child favors." This is a rule-of-thumb approach, but it is a reasonably workable one.

SUMMARY

1. The "whole child" concept of organic growth should be developed in dentistry.

2. Physical growth embraces increase in dimension, change in proportion, and progressive aging.

3. There are three basic principles in organic growth: cellular, or genetic; organizational, or embryonic; environmental, essentially postnatal.

4. Postnatally, during the first two decades, the process of growth is amenable to an age-period classification. Moreover, there is integrative patterning in the "curves" of growth: neural, bodily, lymphoid, genital; face and teeth cut across neural and bodily.

5. Growth progress can be registered via three ages: chronologic (C.A.), dental (D.A.), skeletal (S.A.). The last two are biologic. The last is the basic growth-tempo of an individual.

6. Growth data may be used to evaluate status, assess progress, measure comparability, determine inheritance pattern, and confer individuality.

7. The interpretation of height-weight growth throws light on growth-timing in facial skeleton: from 0:9 to 1:0 *after* the prepubertal height "spurt" begins there is accelerated growth in the facial skeleton.

8. Facio-dental growth is a complex of the calcification and eruption of the teeth plus growth of the facial skeleton in three planes: breadth, height, depth.

9. In the human subject the basic follow-up methods of analyzing facio-dental growth are cephalometric and roentgenographic cephalometric.

10. There is reason to believe that there is unit or trait heredity in teeth, arches, and facial skeletal framework.

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The Handling of Emergencies Requiring Resuscitation in Dental Practice

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Prevention is the best treatment of emergencies. However, emergencies will occur, and being prepared to meet them will frequently save a life. Many of these conditions arise from or during an anesthetic, and many are totally unrelated to the actions of the dentist, but represent a pre-existing disease state. The basic principles of resuscitation or emergent treatment have been well recognized and are being applied by the medical profession. These same principles can and should be recognized by the dental profession.

Clinical and technical improvements are constantly being introduced in order to make resuscitation more effective, and thus to save an ever-increasing number of lives. In discussing resuscitation as it may be practiced by the dentist, it must be remembered that because of the physical limitations imposed by the dental office, the limitation of equipment available, and the fact that, in the large majority of instances, his medical training and experience are limited, the dentist will be restricted in his diagnostic and therapeutic endeavors. Although some of the more intricate resuscitative maneuvers cannot, therefore, be carried out under office conditions, the basic principles remain unchanged.

Effective resuscitation depends on two primary requirements: (1) realization that an emergency exists and that immediate remedial steps are required, and (2) a definite plan of action, formulated ahead of time, so that confusion and delay in treatment are minimized.

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Resuscitative therapy is accomplished in two phases. The *immediate phase* comprises a rapid evaluation of the patient's condition and steps to *restore and maintain vital functions.* This is the phase with which the dentist may have to deal from time to time in his office. The second phase of treatment consists of making an accurate diagnosis, instituting specific therapy, and preventing complications. Obviously this phase is one which may be deferred for a reasonable period of time, until the services of a medical practitioner can be obtained. Its completion requires time, and frequently the employment of special diagnostic aids. The second phase will, therefore, not be elaborated here in detail.

TYPES OF ACCIDENTS REQUIRING RESUSCITATION

A relatively large number of situations may arise in the dental office in which resuscitation is required, but only two constitute the large majority. The first of these is syncope. This condition, which generally is referred to as "fainting," has been defined as "temporary loss of consciousness due to cerebral anemia." Among the predisposing factors of interest to the dentist are pain, surgical instrumentation, emotional disturbance, and dehydration which may occur in hot weather. Syncope is frequently preceded by premonitory signs such as weakness, giddiness, faintness, pallor, nausea and profuse sweating. The pulse is frequently rapid at this stage, and if the condition is allowed to progress, loss of consciousness supervenes. Involuntary micturition and defecation may rarely occur before consciousness returns. Since loss of consciousness may occur also from any of a variety of organic diseases, it is important to be reasonably certain from the patient's history that no such disease is present before making the diagnosis of simple "fainting."

Uncomplicated syncope is a relatively benign accident and is self-limiting in nature; its prevention and treatment are accomplished by relatively simple maneuvers. During the premonitory stage the patient is placed in a near-horizontal position. A cold wet compress applied to the forehead is of benefit. If consciousness has actually been lost the patient is placed in the horizontal position, preferably with a slight head-down tilt or with legs elevated. If consciousness does not return promptly, inhalation of aromatic spirits of ammonia is indicated, as is the administration of oxygen.

In the arteriosclerotic or hypertensive patient a hypotensive episode should demand immediate action. Oxygen should be started immediately and aromatic spirits of ammonia administered. Vasopressers may be indicated if the condition does not respond within a minute to the above therapy.

A simple rule of thumb would be, *if the pulse is fast* use pulse-slowing drugs such as Vasoxyl ¼ to ½ cc. or 5 to 10 mg. (methoxamine hydrochloride), or Neo-Synephrine (phenylephrine) ¼ cc. or 2.5 mg. Both solutions should be given deep intramuscularly, unless a vein is easily accessible. If a vein is used, use approximately half of the dosage and dilute with water or saline. Neo-Synephrine will act faster but will last a shorter period of time. *If the pulse is slow*, then drugs such as methamphetamine (Desoxyn, Drinalfa) become useful. Administration is again intravenous when urgency exists. If not, intramuscular administration of ¼ to ½ cc. is extremely useful.

Probably the next most important group of conditions requiring resuscitation in the dental office consists of reactions to local anesthetics. There are numerous other conditions, however, which may be the cause of accidents: incorrect sedation, either excessive or inadequate; the previous use of depressor agents for hypertension, or of cortisone; cardiac accidents, such as coronary thrombosis or attacks of angina pectoris; diabetic or insulin coma; an overactive carotid sinus mechanism; cerebrovascular accidents; hysteria, overdose of anesthesia; epilepsy and other types of convulsions—these are just a few which may on rare occasions cause trouble. It is important that each of these common forms of accidents be understood, and that the dentist be organized mentally and physically to handle them without confusion or delay.

BASIC PHYSIOLOGIC PRINCIPLES

Life and health depend, in the final analysis, upon the normal progress of the cells which make up the various organs and tissues of the body. Some of these organs, such as the heart, kidneys and brain, are more essential than skin, muscle and bone, for instance. The more specialized its function, the less resistant is the cell to changes in its environment. In order to maintain cellular viability, it is essential that an adequate supply of oxygen be present at all times to permit oxidative and other enzymatic processes to continue uninterrupted. Hence the primary need during resuscitation is to maintain this oxygen supply to vital organs. Two systems are primarily concerned in the transport of oxygen: (1) respiration, or breathing, which supplies the necessary oxygen to the lung alveoli and thence to the pulmonary capillaries, and (2) circulation, which then carries the oxygenated blood to all the parts of the body for utilization. The basic objective, then, of the immediate phase of resuscitation is to maintain or restore an adequate oxygen transport system by support of respiration and circulation.

The oxygen transport system can be interrupted at various stages and by diverse mechanisms. An inadequate supply of oxygen in the inhaled atmosphere will cause an insufficient amount of oxygen to be available to the circulation. The same holds true when respiration is obstructed or depressed. Both of these contingencies may arise during general anesthesia, and obstructions may occur in all states of unconsciousness. In certain cases, disease of the lungs may interfere with adequate diffusion of oxygen into the circulation. In all these states, the accumulation of carbon dioxide (hypercarbia) further aggravates the lack of oxygen (hypoxia).

Again, despite adequate availability of oxygen to the blood, circulation may be impaired because of heart disease, vascular disease or shock, or because there is a diminished amount of hemoglobin available for the carriage of oxygen, as occurs in anemia. Pre-existing shock is not likely to be encountered in the dental office, but heart disease and anemia are definite possibilities. All circulation may be entirely at a standstill, as in cardiac arrest, or breathing alone may be in abeyance, requiring only artificial respiration. The differentiation of these various conditions is essential to proper resuscitative procedures and, although we cannot discuss the differential diagnosis of the various collapse states in this paper, it is essential to proper management of the collapse patient.

HISTORY, PHYSICAL EXAMINATION AND PREPARATION OF THE PATIENT

Many of the more serious accidents can be avoided by merely taking a thorough history from the patient. A history of frequent previous fainting episodes will put the operator on his guard against a recurrence of this phenomenon. A history of a previous reaction to local anesthetics will warn the dentist that trouble may again be in store, and it will be well to elicit information from the patient as to the identity of the local anesthetic drug employed on that previous occasion. If such information is available, it will be prudent to use another local anesthetic of different chemical configuration or, better still, to avoid local anesthesia altogether.

Because of the importance of such information, a patient should always be told what drug has been used in case of reaction, so that he may be able to impart this information to any future operator. He should also be given a letter describing accurately the type of reaction he experienced.

It is extremely important that the reactions be distinguished from psychomotor reactions. If the patient simply fainted or had a reaction to the epinephrine, this has an entirely different connotation than a

true reaction to a local anesthetic. The dentist's records should show the type of reaction, so that he can be forewarned and thus prevent a recurrence. It is important to realize that approximately 97 per cent of the reactions are not true reactions to the anesthetic but are psychomotor and epinephrine reactions.

Inquiry should always be made of the patient to ascertain if any drugs are regularly used or have been prescribed by his physician. The type of drug used may give the dentist information as to whether the patient may suffer from diabetes, heart disease, thyroid dysfunction, and so on. In well advanced cases of rheumatoid arthritis, examination of the patient's hands will show signs of this disease and consequently will put the operator on his guard as to the possibility of the patient's taking cortisone. Frequently, if asked, the patient will volunteer information about any other systemic disease for which he is receiving or has undergone treatment in the past. The operator should inquire whether the patient suffers from chest pain, swelling of ankles, shortness of breath, dizziness, or palpitation, as all of these may denote heart disease.

In order to simplify history taking and to save the dentist time, the office nurse or receptionist may make used of a card on which are the following questions pertaining to medical history:

1. Have you followed the pre-operative instructions?
2. Have you ever had an anesthetic?
3. Have you ever been hospitalized?
4. Is there anything special about physical condition that should be called to our attention?
5. Have you ever had rheumatic fever?
6. Have you been ill this past week?
7. Have you ever had any profuse bleeding?
8. Have you ever had joint pains or stiffness?
9. Are you allergic or sensitive to any drugs? Which_____; dosage_____; duration of treatment_____.
10. Have you had any:
    a. Lung surgery
    b. Heart surgery
    c. Blood vessel surgery
    d. Adrenal surgery
    e. Thyroid surgery
    f. Brain surgery
    g. Nose surgery
    h. Nose or face fractures
11. Do you have sudden spells of dizziness or shortness of breath?
12. Have you ever had a nervous disorder?
13. Do you have attacks of pain in your chest?
14. Do you have any swelling of the feet or ankles?
15. Is there any reason why you think you should not be given a local, or a general anesthetic?
16. Do you take or have you taken any drugs or medicines in the past few years? If so, what?

On the basis of the answers to his inquiries, the dentist will gain valuable information. Whenever it is determined that the patient has been or is under medical care, it would be well for the dentist to obtain clearance from the attending physician.

Although the dentist usually is not equipped to make a definite clinical diagnosis of systemic diseases, there are many signs which may indicate whether his patient is in good health or not. Shortness of breath, cyanosis of lips and finger nails, and clubbing of fingers may be indicative of either cardiac or pulmonary disease; if associated with enlargement of the veins of face and neck, they may mean actual or imminent cardiac decompensation. Swelling of the neck, with tremor of fingers and sweating of the palm may signify thyroid disease. Puffiness of the eyelids and dizziness may be indicative of kidney disease. Pallor, especially of the lips and other mucous membranes, recalls the possibility of anemia. A flushed skin, perspiration, and glassy eyes may denote fever. The diagnosis of an impending or actual cold is obvious. The pulse should be observed for rate, filling and regularity. Disease should be suspected if the pulse is abnormally rapid or feeble, or is irregular in either rate or filling. Respiratory rate and character are of utmost importance in judging physical state.

In all these instances, the patient should be referred to his physician for diagnosis and necessary treatment of his disease, and dental work should be delayed until medical clearance is obtained. Even then it may be advisable in some instances to carry out the dental procedures in a hospital rather than in the office.

In order to minimize accidents from aspiration of vomitus, patients should refrain from taking food or liquid for at least 4 hours preceding the appointment. This rule applies irrespective of the administration of the general anesthetic, since unconsciousness from any cause carries the risk of aspiration.

When local anesthesia is planned, premedication with secobarbital (Seconal) or pentobarbital (Nembutal) 0.1 Gm. (1½ grains) 1 hour before anesthesia will reduce the incidence or severity of reactions to the local anesthetics. Phenergan (promethazine) 50 mg. intramuscularly and Demerol (meperidine) 50 mg. intramuscularly is a good mixture for the hospitalized patient. If given approximately 90 minutes before time of surgery, it will aid markedly in diminishing psychomotor reactivity. If this mixture is used in ambulatory patients, they should be accompanied by some responsible person.

ARMAMENTARIUM

Since resuscitation depends primarily on the re-establishment of an adequate oxygen transport system, means must be available in every

dental office for the basic requirements to maintain circulation and respiration. The one single, most useful and universally applicable agent to deal with patients requiring resuscitation is oxygen. This implies the availability of a tank with proper regulator, a mask and a breathing bag all ready for instantaneous use. Furthermore, a series of airways of different sizes should be available, as should also an instrument to pry open the jaw and one to hold the tongue forward out of

TABLE 1. *Emergency Armamentarium for Office Resuscitation*

MATERIAL	USE
Aerosols (anti-asthmatic)	Anti-asthmatic
Airways, oral and nasal	Respiratory obstruction
Amyl nitrite	Anginal attacks
Analgesics (narcotic and non-narcotic)	For pain
Antihistamine solutions, injectable	Drug and allergic reactions
Aromatic spirits of ammonia	Respiratory stimulant
Atropine solution	Vagolytic and "drying agent"
Caffeine sodiobenzoate	Little harm—little good
Desoxyephedrine	Analeptic vasoconstrictor
Epinephrine	Dangerous—angioneurotic edema and asthma
Evipal	Sedative, hypnotic
Gelfoam	Local bleeding
Glucose solution	Hypoglycemia
Hydrocortisone	Hypoadrenal states
Hypodermic syringes and needles	Administration unit
Lorfan	Antinarcotic agent
Mask	Mouth-to-mask respiration
Nitroglycerin tablets	Anginal attacks
Neo-Synephrine	Vasopressor
Oral screw	Open closed mouth
Oxycel	Control bleeding
Oxygen (and administration unit)	Support respiration
Saline for injection	Vehicle for injection
Sedative	Sedation
Suction catheters and tubes	Remove secretions
Tongue forceps	Aid in maintaining airway
Tourniquet	Intravenous therapy
Tracheotome (emergency type)	Emergency tracheotomy
Vasoxyl	Vasopressor
Water for injection	Injection

the posterior pharynx. A source of suction capable of clearing the airway of vomitus is also essential. These few and inexpensive items are all that are needed for adequate control of respiration and to deliver a sufficient amount of oxygen to the pulmonary circulation.

Even less equipment is required for support of circulation. Syringes of 2.5 cc. and 10 cc. capacity with needles are required, together with a few drugs (see Table 1); the pharmacology and place of these drugs in clinical practice should be known by all practitioners.

Epinephrine (Adrenalin) and the various analeptics such as nikethamide (Coramine), pentamethylenetetrazol (Metrazol) and picrotoxin are to be avoided. Caffeine sodium benzoate, a mild analeptic, may be given if desired, but probably serves little useful purpose, and the time spent in its administration may be more efficiently utilized.

Epinephrine, which for many years has been a standard part of the practitioner's armamentarium in an emergency, deserves special comment. This drug has a real use in the dentist's office as a local vasoconstrictor. It is a very useful drug in status asthmaticus and in angioneurotic edema or similar allergic states, but here its usefulness ends. It is a drug which has the following definite disadvantages: It causes an extremely rapid and undesirably high elevation of blood pressure, and frequently extreme tachycardia. This causes a considerable increase in the work of the heart and may lead to an arrest of the heart due to ventricular fibrillation. It also causes tremors, shaking chills, anxiety and nervousness. The oxygen utilization is increased by the drug at a time when the supply may be limited. Above all else, there are safer analeptics that act rapidly with fewer side actions—an example would be phenylephrine (Neo-Synephrine).

It should be emphasized here that every dental office should be equipped with a chair which can quickly and easily be tilted into the horizontal position, as this is a prerequisite for successful resuscitation. A stethoscope and sphygmomanometer would be advantageous if the dentist has the training to use them.

RESUSCITATIVE MEASURES

Whatever the emergency requiring resuscitation, a number of basic steps should always be taken. The patient should be placed immediately in the horizontal position on his back, preferably by rapid adjustment of the chair. It is of advantage to tilt the patient in a slight 5 degree head-down position, or else to elevate the legs, in order to facilitate return of blood to the heart and increase the blood supply to the brain by means of gravity. The central nervous system is the first to suffer from oxygen lack, and the position just described will shunt blood to the brain at the expense of less critical organs. He is allowed to inhale aromatic spirits of ammonia. Oxygen is administered immediately by mask, and if respiration is inadequate, as judged by shallow respiration, or if air hunger exists, as indicated by rapid, effortful breathing, respiration is assisted by compressing the breathing bag in synchronization with the patient's own respirations.

If no respiratory effort is being made, the mask is firmly applied to the patient's face and artificial respiration is performed by slow, rhyth-

mic compression and sudden relaxation of the bag at the rate of 16 to 20 strokes per minute. In the latter instance, consciousness will have been lost and care must be taken to maintain an unobstructed airway. This is best done by holding the chin forward. In this maneuver, the middle fingers are inserted behind the angles of the mandible, while thumbs and index fingers secure the mask against the face.

The airway may be further improved by turning the head to one side or the other. If this fails to maintain absolutely unobstructed breathing, an artificial airway of suitable size should be inserted in such a way that the curved end of the airway comes to lie between the base of the tongue and the posterior pharyngeal wall. Too short an airway may actually increase the obstruction by pressing upon the dorsum of the tongue and forcing the base of that organ to be pressed against the pharynx.

A free airway and adequate ventilation having thus been assured, a rapid check should be made of the state of circulation. In the majority of instances when mere fainting has occurred, the patient will regain consciousness within a very few minutes after being placed supine, frequently even before oxygen administration has begun. Nevertheless, oxygen administration should be instituted until the patient is fully conscious and the pulse is of good volume and slow rate. Such a patient should not be allowed to sit up for some time, and then should be allowed to elevate the head only slowly and gradually until he is able to sit without recurrence of symptoms.

If a patient has ceased to breathe and oxygen is not available, artificial respiration should be instituted. In choosing a suitable method, it should be borne in mind that it is better to place the patient in a face-down position with the head turned to one side, as this will more certainly promote a free airway without special precautions, and will also allow saliva and vomitus to drain away rather than be aspirated. The various available methods of artificial respiration have been thoroughly investigated, and it has been found that, all else being equal, the arm-lift back-pressure or arm-lift chest-pressure techniques will give the best tidal volume with less exertion on the part of the operator. For a detailed description of these and other methods, the reader is referred to the work of Gordon, Sadove, Raymon and Ivy.[1]

Recent work by several investigators, and other reports which are at present in press, have thrown some very interesting light on the subject of artificial respiration. These workers have all concurred in the opinion that mouth-to-mouth or mouth-to-mask or mouth-to-airway means of artificial respiration is extremely efficient and effective. In fact, from a practical aspect it is much more efficient than manual artificial respiration. The ease with which obstruction occurs in manual

methods and the ease with which it can be overcome in the mouth-to-mouth or airway techniques is striking. Space does not permit adequate discussion of the technique, but every dentist should read in detail these articles[2] and know and be able to use the techniques.

If, despite these measures, the patient shows no improvement, and evidence of circulatory impairment becomes obvious, treatment must be undertaken to combat the failing circulation. Usually the intravenous injection of a vasopressor is required, and this should be done. It is recommended that preferably phenylephrine hydrochloride (Neo-Synephrine) be injected intravenously in a dose not exceeding 2 mg. If facilities for intravenous injections are not available, phenylephrine hydrochloride 5 mg. should be combined with 150 turbidity-reducing units of hyaluronidase, and this combination injected deeply intramuscularly. Response to the intramuscular injection is very much less prompt than it is to intravenous injection. Hyaluronidase increases the spread and absorption of these agents, but probably at least 3 minutes will elapse before a significant result is obtained. If hyaluronidase is not available, the injection should nevertheless proceed, but a corresponding delay in effect must be expected.

Reactions to local anesthetics will frequently be marked by symptoms of cardiorespiratory failure and should be treated along the line indicated above. However, if the reaction is one in which central nervous system stimulation is predominant over depression, as evidenced by muscle twitching or convulsions, the stimulating effect of the local anesthetic drug should be counteracted by a cortical depressant such as thiopental (Pentothal) sodium, Evipal or similar rapid acting barbiturates. Oxygen therapy must be continued throughout. It is suggested that a 0.2 per cent solution of thiopental be prepared by dissolving 0.5 Gm. in 250 ml. of sterile water (or 5 per cent dextrose in water or normal saline) and that just enough of this solution be injected intravenously slowly until all signs of muscle twitching have disappeared. The amount needed to just control the muscle twitching should under no circumstances be exceeded. This solution must be given intravenously and cannot be injected intramuscularly or subcutaneously.

If complete circulatory standstill is suspected, on the ground of absence of heart tones over the precordial region, atropine 1 mg. and phenylephrine 10 mg. should be rapidly injected intravenously in 20 cc. of saline in the hope that a weak circulation is present which will carry the drug to the effector organs. No benefit can be expected from this maneuver if cardiac arrest has actually resulted. On rare occasions, percussion over the region of the heart may restart this organ but this procedure cannot be relied on as being invariably successful. If one

is absolutely certain that the heart has ceased to beat, an attempt may be made to stimulate it by introducing a 3 inch needle directly into the heart through the space between the third and the fourth rib on the left side of the sternum. Should the heart fail to respond, then epinephrine 0.1 cc. of 1:1,000 solution may be injected into the heart. Drugs such as Isuprel (0.02 mg.) or the atropine and Neo-Synephrine mixture are probably safer than epinephrine for the dangerous procedure of intracardiac injection. However, this must be done within the first 3 minutes.

No attempt is made here to go into the details of manual systole (cardiac massage), fluid administration, blood transfusion, and so on, as none of these maneuvers can be carried out in the dentist's office. The facilities for this type of treatment usually are not available in a dental office.

In all treatment involving resuscitation, it must be borne in mind constantly that an adequate amount of oxygen must be supplied to vital tissues and that the brain is the organ most vulnerable to oxygen lack. Hence, consciousness is lost early in all cases of oxygen want. It is of the utmost importance, therefore, to maintain an adequate supply of oxygen to this very sensitive organ, as otherwise irreparable damage to nervous tissue will ensue which is not compatible with life or with restoration of full nervous function. The steps outlined herein should assure this end within the obvious limitations of the dental office setup.

SUMMARY AND CONCLUSIONS

Most accidents in the dental office are of a minor nature and will respond to the procedure of placing the patient in the supine position with legs elevated, and administering oxygen. Rarely will stimulants and vasopressors be required, but if the patient fails to respond to the administration of oxygen, they should be employed without hesitation. It must be remembered that the adequate supply of oxygen to vital organs depends on the integrity of the respiratory and circulatory systems. If a catastrophe of the magnitude of cardiac arrest does arise in the office, the chances of salvaging the patient are extremely small. Yet, the few maneuvers available to the dentist under those circumstances should nevertheless be employed.

Much difficulty can be avoided by taking a good history and by obtaining medical clearance in all doubtful cases. Every patient who has required resuscitation should be referred to a physician's care so that the condition underlying the accident may be evaluated and the necessary precautionary treatment may be instituted if organic disease is present.

Nothing is said in this paper regarding the second phase of resuscitation, that of specific therapy and prevention of complications, since this is outside the category of emergency treatment and involves procedures for which the dentist usually is not equipped.

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The Relationship of Oral Infection to the Eye

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Every dentist has a healthy respect for the unusually virulent oral infection which may be a threat to life itself. Not all dentists realize, however, that many times an obscure and relatively benign-appearing oral infection can be the cause of a "red hot eye" which can lead to blindness. Appreciation of this danger by the dentist is essential to fruitful cooperation with the ophthalmologist, and to proper teamwork in behalf of the patient.

The role of dental infection in diseases of the eye is more important than is generally realized. This dictum depends upon acceptance of the concept that focal infection elsewhere in the body can affect the eye. Some physicians and dentists do not believe in this mechanism. No all-embracing experimental evidence has been put forward to place this concept beyond all doubt; however, certain causes of endogenous uveitis have been established, and clinical experience of a most persuasive nature leads many to think it necessary always to search for focal infection when confronted by a patient with uveitis.

There is no other organ in the body which can be observed so closely during health and disease as can the human eye. One cannot look into the tissues of the joints, the heart, or the prostate gland to follow their responses to inflammation, but the eye does offer an excellent opportunity for study of focal infection. With the biomicroscope (slit lamp and corneal microscope), one can observe cells circulating in the aqueous, single cells or agglutinated clumps of cells deposited on the posterior surface of the cornea, serous and fibrinous exudates, engorgement of the delicate stroma of the iris, membrane formation in the pupillary area, and the development of posterior synechias (adhesions of iris to the lens). Cells in the anterior vitreous can also be studied with the slit lamp. With the ophthalmoscope or

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with a special lens and the slit lamp, the entire depth of the vitreous can be seen in detail.

Because of the facility with which these examinations can be made, the ophthalmologist has an ideal opportunity to study active inflammation in situ. These examinations can be repeated as often as desired from the very onset to subsidence of the inflammatory reaction. It is interesting to note the rapidity with which changes occur in the aqueous humor. Within a half hour after a blunt blow to the eyeball, circulating cells and increased flare can be seen in the aqueous. Conversely, when the cause of an endogenous iridocyclitis has been removed, there is a rapid (24 hour) change for the better reflected in the aqueous humor.

Uveitis, also called iridocyclitis or choroiditis depending upon the portion of the uveal tract involved, is never primary in the eye. Iridocyclitis or choroiditis can be very serious in itself. Three other major eye diseases can be caused by inflammation of the uveal tract or retina, alone or in combination. These are secondary glaucoma, cataract, and detachment of the retina. *Each of these can cause blindness.*

Sometimes this cause-and-effect relationship is quite clear; in many instances a very mild uveitis may be present but asymptomatic. Indeed, it is only by careful routine slit-lamp examination with and without dilatation of the pupil that the ophthalmologist can find evidence of such subtle inflammation. Many times the cataract is mature, the secondary glaucoma well established or the retina already separated before the patient is seen by an ophthalmologist for the first time. By then the cells or increased protein content of the aqueous may be gone, and there may be no definite evidence of past or "burned out" inflammation. Comparision of such eyes with others seen during the active phase of uveitis which later produced cataract, secondary glaucoma or separation of the retina permits us to draw the logical conclusion that the two were affected by the same mechanism, i.e., endogenous inflammation.

Endogenous uveitis may properly be considered as the most important disease process affecting the eye. This being so, it behooves us to search for the causes of uveitis. Many causes are known and have been established by means of culturing the organism, by identification of the organism in histopathologic section, by observing therapeutic response, and the like. The causative agents responsible for granulomatous uveitis have been demonstrated; some of the agents responsible for non-granulomatous endogenous uveitis have also been demonstrated, such as the gonococcus and the streptococcus. In some of both types, bacterial allergy plays a definite role. In a large percentage of eyes with non-granulomatous inflammation, no cause is

found. In some instances the most exhaustive search leads to no conclusion. When the search has been only cursory, it may be necessary to make a second survey of a more complete type in order to find a focus of infection.

In addition to uveitis, tenonitis, episcleritis, and optic neuritis can be due to dental foci of infection.

Those who doubt the occurrence of focal infection should be given the opportunity for daily slit-lamp study of an eye with iridocyclitis. Let us say that the patient has an abscessed tooth and no other probable cause is found. The inflammation persists, usually becoming worse until the abscessed tooth is extracted. Then in 24 hours, a tremendous improvement can be observed. It is wise to give the patient some antibiotic prior to extraction of infected teeth lest there be some focal flare-up in the eye, even though such a flare-up is not often observed clinically. There may be other sites of involvement, such as the joints or the heart; the latter may be made much worse by sudden release of bacteria, especially streptococci, into the blood stream. It is this type of dramatic response in the eye following treatment or removal of a focus of infection, such as an infected tooth, that convinces many ophthalmologists of the reality of a cause-and-effect relationship. It is true that the uveitis may not respond to removal of such foci, but the ophthalmologist can scarcely be excused from making every effort to track down and eliminate such possible sources of the uveitis. Consequently, he will refer his patient to the dentist, and rely upon him to appreciate the problem and carry out the proper procedures for the benefit of the patient.

In his book, *"Oral Medicine—Diagnosis and Treatment,"* Burket presents an excellent discussion of dental focal infection and enumerates the types of oral infection which can affect the eye:

1. Periodontal foci.
2. Periapical foci, even in edentulous patients, as many have root fragments, unerupted teeth, and simple areas of residual inflammation.
3. Vital pulp infections.

One can suspect foci of infection:

1. In those with a history of preceding dental abscesses, especially if there was ocular or joint involvement, or similar focal infection at that time.
2. In patients whose mouths show evidence of neglect manifested by accumulated food and debris, erosion of gums and deep cavities.
3. In patients with poorly fitting crowns or inlays or with discolored teeth.
4. In patients with missing teeth if the remaining teeth are not clean and healthy. One should always ask why these teeth have been lost.

5. In patients who have had periodontal disease, which can produce pockets of pus which do not drain.

When the ophthalmologist refers his patient to the dentist, he wishes to have a complete and thorough examination for any possible focus of infection and immediate treatment thereof.

The ophthalmologist depends upon the dental consultant to determine the best method of eliminating the infection—extraction of the tooth, resection of the root and drainage of the abscess, surgical removal of infected gingival tissue, or medical treatment. Some periapical foci can be adequately treated without extraction of the tooth. Periodontal disease often responds to medical treatment and better hygiene, perhaps combined with excision of part of the gingival tissue. Treatment in general should be aimed at prompt elimination of any of the above-mentioned types of oral infection.

The speed with which oral infections are eradicated is of paramount importance. Delay allows progressive destruction of function, and irreversible changes in the ocular tissues. An example of this is the effect of inflammation on the crystalline lens. If opacification has reached a certain stage, complete cataract formation will inevitably ensue. Here one sees that early removal of focal infection may prevent cataract formation, whereas delayed removal will not affect this process at all. One sees that the *timing* of treatment must be taken seriously. The ophthalmologist should urge the dentist to take a certain patient as an emergency, and *the dentist should respond even though it upsets his schedule.*

Since the eye can be so closely followed before and after treatment of dental foci, close cooperation between physicians and dentists permits evaluation of the effect of the dental treatment, whatever it may be. If the eye does not respond well following treatment of all dental foci, one must conclude that either the treatment is inadequate or the dental focus has not been responsible for the ocular inflammation.

This leads us to a less well appreciated phenomenon, that one focus can create another—that is, dental infection can cause prostatitis, which in turn can be responsible for ocular infection. Both foci can be present as purely coincidental infections, neither being responsible for the other. Also, dental infection may cause both arthritis and iridocyclitis, for example. Proof of a causal relationship is not absolute; certainly, two foci of infection can exist simultaneously and independently. But clinical evidence is often so strong and therapeutic response so remarkable that, for practical purposes, we can say that a cause-and-effect relationship exists. One can discuss academically the pro's and con's, finally settling the problem by basic plus clinical research.

In summary, one can say that medico-dental cooperation of the closest kind is essential in eliminating the cause of some forms of ocular inflammation. Still more good could be done by education of the public by the medical and dental professions together about the advisability of prevention of focal infections and routine periodic examination of the eyes.

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